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Mexico's macroeconomic performance: an analysis using co-integration techniques

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Mexico's macroeconomic performance:

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CHAPTER 1. INTRODUCTION

Recent developments in applied time series analysis emphasize the importance of stationary time series and testing for the existence of long-run relationships, or, equivalently, testing for co-integration. In econometric empirical research, stationarity in a variable is an important property for several reasons. First, stationarity guarantees that the effects of a random disturbance on a variable will die out over time. Second, the regression estimators of a regression with nonstationary variables will not be consistent. And third, it is important to determine if variables are stationary when estimating or testing for statistical, stable long-run or equilibrium relationships among key variables. The issue here is that applied modern econometrics emphasizes the utilization of stationary time series, i.e., time series with no unit roots.

Traditionally, when a set of variables appeared to be nonstationary, in some instances, their nonstationarity was removed by taking first or second differences of such series. One down side of that approach is that if the time series involved observed a long-run or equilibrium relationship, or if their nonstationarity arose from the same common source (i.e., they shared a common stochastic trend), then they should be modeled as co-integrated variables and not as differenced variables. Co-integration among a set of variables means that even though each specific variable is nonstationary by itself, a particular linear combination with others is stationary. Co-integration theory argues against differencing because differencing removes much of the long-run characteristics of the data. Furthermore, modeling co-integrated data in differences will result in specification error, while modeling that data in levels will overlook important statistical relationships or constraints. In this case, the modern time series approach suggests modeling co-integrated variables as an error-correction model. Such a model consists of a long-run error-correction term together with the first difference of the variables under study, which allows for the short-run dynamics of the model.

Studies that test for co-integration using Mexico's data are uncommon. In this research, co-integration and vector autoregressions techniques are used to test for statistical evidence of long-run or equilibrium relationships among time series of Mexico's balance of payments, exchange rates and monetary aggregates. The results obtained are reported in chapters three through five.

The second chapter of this dissertation presents a discussion of Mexico's macroeconomic performance and trade policy and industrialization during the period 1957-1991.

Chapter three presents an analysis of Mexico's balance of payments and the exchange rate during the period 1971-1988. In the context of the monetary approach to the balance of payments, this chapter provides statistical evidence that, despite the presence of nonstationarity in Mexico's data, a long-run relationship seems to exist between changes in international reserves and the exchange rate and changes in domestic credit, i.e., these variables seem to be co-integrated. In addition, multivariate Granger causality tests and innovation accounting support a negative bidirectional causality between these variables which do not support the unidirectional causality of the monetary approach, or its assumption that domestic credit is exogenous. The bidirectional causality also indicates that Mexico's monetary authorities adjust domestic assets to sterilize exogenous balance-of-payments deficits on the monetary base in an attempt to control its monetary policy.

In chapter four, once again, co-integration and vector autoregressions techniques are applied to Mexico's data to test whether purchasing power parity holds during the period 1960-1988. The null hypothesis of non co-integration (e.g. purchasing power parity does not hold) was rejected in favor of accepting purchasing power parity. An estimated error-correction model suggests that Mexican prices and/or the peso price of a U.S. dollar adjusted to maintain purchasing power parity during that period. Furthermore, innovation accounting and Granger causality tests derived from the estimated vector autoregressions also support the finding that Mexican prices and/or nominal exchange rate adjust to maintain purchasing power parity.

In chapter five, co-integration techniques are again applied to Mexico's data to determine whether there exists statistical evidence of a long-run or equilibrium money demand specification during the period 1969 to 1991. Although three definitions of money supply are used, only the monetary aggregate M3 seems to observe a long-run relationship with income and the rate of inflation.

In chapter six, the overall conclusions are presented. Finally, two appendices contain the results of testing for unit roots under structural breaks, and the data set utilized in this dissertation.

CHAPTER 2. OVERVIEW OF MEXICO'S MACROECONOMIC PERFORMANCE AND TRADE POLICY AND INDUSTRIALIZATION DURING THE PERIOD 1957-1991

Overview of Mexico's Macroeconomic Performance During the Period 1957-1991

In this section, a description of Mexico's post-war economic performance is presented in several stages: the "Stabilizing Development" that covers the years 1957-1970, the "Shared Development" that ran from 1971-1977, the "Oil Boom" comprising the years 1978-1982, and the period of "Fiscal Correction and Stabilization" that started in 1983 and continues to the present (November 1993).

Stabilizing development, 1957-1970

During the "Stabilizing Development" from 1957 to 1970, the Mexican economy grew at a rate of 7.2 percent, while inflation averaged 3.6 percent in an environment of moderate fiscal and monetary policies.[1] The average 1957-1970 growth rate in money supply (currency plus demand deposits) was 10.8 percent while the average 1960-1970 public sector

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[1]Antonio Ortíz Mena, Secretary of Mexico's Treasury from 1959 to 1970, called the period 1957-1970 "Stabilizing Development" in 1969 and thereafter it was commonly referred to as such, see Antonio Ortíz Mena (1969).

Table 2.1. Mexico's Macroeconomic Variables, Period Averages

Concepts	1957-1970	1971-1977	1978-1982	1983-1988	1989-1991
GDP Growth Rate	7.2	5.6	7.1	0.2	3.8
Inflation Rate	3.6	15.7	35.9	83.4	22.7
Public Deficit as a Percent of GDP [a]	-1.5	-6.4	-10.4	-11.8	-2.6
Current Account as a Percent of GDP	-2.7	-3.3	-4.3	1.1	-3.5
M1 Growth Rate	10.8	21.9	26.1	67.5	71.3

Source: Banco de México, Indicadores Económicos; and INEGI, Cuentas Nacionales.

Notes: GDP = Real Gross Domestic Product; Inflation Rate = Percentage change in the end-of-period Consumer Price Index; Public Deficit = Public Sector's Financial Requirements; and M1 = Currency plus Demand Deposits.

[a] Refers to the period 1960-1970. Data for previous years are not available.

financial requirements relative to GDP was -1.5 percent (see Table 2.1).

According to Zabludovsky (1989), the combination of high growth and low inflation during the period 1957-1970 appeared to be the result of mainly three policies: (1) low public sector deficits relative to GDP, (2) stable money supply growth, and (3) positive real interest rates. Zabludovsky (1989) also noted that positive real interest rates were important to the extent that they resulted in increasing financial savings during that period. The combination of positive interest rates and relatively low public sector deficits, Zabludovsky noted, allowed the Mexican government to finance its public sector deficits without much debt monetizing or foreign borrowing.

Mexico's macroeconomic performance can also be described by dividing the period we are interested in into six-year periods that coincide with each new administration. In most cases these six-year periods, that correspond to the presidential political cycle, also coincide with Mexico's business cycle. For the most part, a typical Mexican administration period would be characterized by a first year of restrictive fiscal and monetary policies and a last year of strong expansionary aggregate demand, as government spending would be increased in the last year to finish public investment programs, (see Beltrán del Río (1973), and

Table 2.2. GDP Per Capita, Inflation and Real Minimum Wage in Mexico
Growth Rates Expressed as Period Averages in Percentage

Period	President	GDP Per Capita	Inflation	Real Minimum Wage
1935-40	Lázaro Cárdenas	2.8	5.9	-2.0
1941-46	Manuel Avila Camacho	3.5	17.7	-7.3
1947-52	Miguel Alemán Valdéz	3.1	11.2	3.8
1953-58	Adolfo Ruíz Cortines	3.5	6.7	0.5
1959-64	Adolfo López Mateos	3.3	2.3	11.1
1965-70	Gustavo Díaz Ordaz	3.4	3.6	4.0
1971-76	Luis Echeverría Alvarez	2.7	14.1	2.3
1977-82	José Luís López Portillo	3.1	30.5	-3.3
1983-88	Miguel De La Madrid	-1.8	83.4	-8.8
1989-91	Carlos Salinas De Gortari	1.8	22.7	-7.1

Source: Eliana A. Cardoso and Santiago Levy (1988); Banco de México, Annual Reports and Comisión de Salarios Mínimos. Updated by the author from 1983-1991.

Cardoso and Levy (1988)).

During the administrations that comprised the "Stabilizing Development" (the period from 1957-1970), GDP per capita averaged more than 3.3 percent; average inflation was between 2.3 and 6.7 percent; and average real minimum wage rate grew at positive rates, reaching 11.1 percent during the López Mateos administration (see Table 2.2). Such rates of growth seem to suggest that the Mexican "Stabilizing Development" was successful in achieving relatively high economic growth, low inflation and some gains in real wages. However, the stabilizing development model led to significant government intervention in Mexico, making its economy highly dependent on imported inputs and capital goods from abroad. This intervention also led to a highly distorted price system that resulted in an industry that was inefficient with low productivity and low quality, producing mostly for the domestic market.[2]

Shared development, 1971-1977

During 1971, the first year of the Echeverría administration, economic policies were somehow conservative. However, by his second year in office fiscal and monetary

[2]The Mexican "Stabilizing Development" corresponds to the model of development described in the literature as Import Substitution Industrialization. See the section on trade and industrialization.

policies became very expansionary. Clearly, the moderate policies that Mexico followed under the "stabilizing development" had been abandoned. For one thing, relative to GDP, the public sector deficit almost doubled to -4.5 percent in 1972 from -2.3 percent in 1971. Second, the growth in money supply (demand deposits plus currency in the hands of the public) increased from 7.7 percent in 1971 to 21.2 percent in 1972. By year-end 1972 GDP growth reached 8.2 percent and inflation increased slightly to a 5.7 percent rate from 5.0 percent of the previous year (see Table 2.3).

With these results in mind--expansionary monetary and fiscal policies resulting in higher GDP growth and relatively low inflation--and in spite of the acceleration of inflation in 1972, the Echeverría administration adopted a more active government involvement in the economy throughout his mandate. By 1976 this "public-expenditure-led growth model" resulted in a rate of inflation of 27.2 percent, and a GDP growth rate of 4.4 percent; both of which did not fare well when compared to the average 1960-1970 values of 2.8 percent in inflation and 6.6 percent in GDP growth. Also, the public sector deficits continued to increase sharply, reaching -9.1 percent relative to GDP in 1976; a figure that is much higher than the average 1960-1970 of -1.5 percent. In addition, both the deterioration

Table 2.3. Mexico's Macroeconomic Indicators[a]

	Annual Percentage Change in:				Real
Year	GDP	CPI	M1	Investment	Interest Rate
1960	8.1	4.9	9.4	14.9	
1961	4.3	-2.0	4.9	0.9	4.7
1962	4.5	2.1	13.0	2.2	4.3
1963	7.5	-0.1	15.7	13.2	5.6
1964	11.0	3.5	16.3	21.7	1.4
1965	6.1	4.5	6.2	4.0	4.4
1966	6.1	3.8	11.0	9.8	4.4
1967	5.9	3.1	7.6	11.6	3.7
1968	9.4	1.8	12.7	9.8	4.2
1969	3.4	2.6	10.6	6.9	3.9
1970	6.5	7.1	10.4	8.1	1.2
1971	3.8	5.0	7.7	-1.7	0.9
1972	8.2	5.7	21.2	12.2	2.3
1973	7.9	21.3	26.7	14.7	-3.6
1974	5.8	20.6	20.1	7.9	-9.9
1975	5.7	11.3	21.1	9.3	-2.4
1976	4.4	27.2	35.7	0.4	-3.0
1977	3.4	20.7	26.3	-6.7	-12.2
1978	9.0	16.2	31.6	15.2	-3.3
1979	9.7	20.0	33.7	20.5	-2.0
1980	9.2	29.8	33.4	14.7	-2.5
1981	8.8	28.7	33.3	16.2	3.2
1982	-0.6	98.9	54.1	-16.8	-8.0
1983	-4.2	80.8	41.4	-28.3	-20.4
1984	3.6	59.2	62.3	6.4	-8.9
1985	2.6	63.7	53.8	7.9	1.1
1986	-3.8	105.7	72.1	-11.8	0.4
1987	1.7	159.2	129.7	-0.1	-15.4
1988	1.2	51.7	58.1	5.8	-29.6
1989	3.3	19.7	40.7	6.3	10.1
1990	4.4	29.9	62.6	13.2	2.6
1991	3.7	18.8	118.6	8.5	-3.6

Source: Banco de México, Annual Reports; and Secretaría de

[a] GDP=Gross Domestic Product; CPI=End-of-Period Consumer Price Investment; Interest Rate=3-Month T-Bill (CETES); Real Wage Index implies Peso Depreciation; Nominal Exhange Rate refers to Period November 11, 1991; Public Sector Deficit as a Percentage of GDP;

Financial Requirements of Public Sector	Real Wage Index 1971=100	Real Exchange Rate Index 1971=100	Nominal Exchange Rate Pesos per U.S. Dollar	Terms of Trade Index 1971=100
-1.4	68.1	100.8	12.5	87.2
-1.2	66.5	100.3	12.5	88.2
-0.8	72.7	100.2	12.5	82.1
-1.2	81.9	100.8	12.5	88.2
-0.6	84.4	99.8	12.5	84.6
-0.8	89.6	98.0	12.5	83.6
-1.1	91.2	96.8	12.5	85.5
-2.1	94.7	96.6	12.5	84.0
-1.9	96.6	98.4	12.5	91.1
-2.0	100.2	100.3	12.5	92.2
-3.4	99.5	101.0	12.5	100.1
-2.3	100.0	100.0	12.5	100.0
-4.5	105.9	98.4	12.5	101.7
-6.3	103.0	93.3	12.5	120.8
-6.7	105.6	83.7	12.5	81.5
-9.3	110.1	79.3	12.5	73.6
-9.1	122.1	89.2	20.5	119.7
-6.3	124.5	108.0	22.6	123.6
-6.2	121.2	99.7	22.7	113.9
-7.1	119.3	93.9	22.8	94.3
-7.5	114.1	85.1	23.0	112.8
-14.1	125.0	78.3	24.5	126.8
-16.9	123.4	116.0	57.4	86.1
-8.6	83.8	131.2	120.2	69.4
-8.5	76.9	115.6	167.8	70.8
-9.6	80.8	116.0	257.0	72.4
-15.9	74.3	150.4	611.4	52.9
-16.0	72.8	151.6	1366.7	67.0
-13.0	72.7	122.2	2250.3	60.4
-5.6	81.0	115.6	2453.2	64.5
-3.9	83.4	109.9	2807.3	73.9
-1.5	87.8	100.2	3006.8	64.0

Hacienda y Credito Público, Annual Reports.

Index; M1=Currency + Demand Deposits; Investment=Gross Domestic
of Manufacturing Sector; An increase in Real Exchange Rate
Average of the Controlled Rate from December 20, 1982 to
It excludes privatizations. (-) means deficit.

of the public sector finances and fixed nominal interest were accompanied by a continued declining in total fixed investment. By 1976, total fixed investment grew by only 0.4 percent with respect to the previous year (see Table 2.3).

Throughout most of the Echeverría administration, the Mexican economy endured a combination of a fixed exchange rate and inflation rates that were higher than those of the U.S., Mexico's main trading country.[3] Such a combination was accompanied by a continuous real appreciation of the Mexican currency together with considerable increasing current account deficits. Current account deficits which had averaged about -.5 billion dollars in the period 1960-1970, expanded to about -.9 billion dollars by 1971. Thereafter, they rose rapidly, reaching -3.7 billion by 1976.

The increasingly larger deficits in Mexico's current account were accompanied by an even higher accumulation of external debt. That is, the increase in external debt was far greater than what was required by the current account alone. For instance, the 1971-1976 average of the current account deficit was -2.5 billion dollars as compared to the

[3]For the most part, Mexico's trade is with the U.S. For instance in 1991 Mexico exported to the U.S. about 79.5 percent of its total exports, while its imports amounted to about 73.7 percent, (The Mexican Economy, 1993, Banco de México).

same period's average of net flow of total external debt of 3.3 billion dollars. Moreover, the item Other Capital Flows and Errors and Omissions showed some negative increasing values, particularly since 1973, suggesting some capital flight (see Table 2.4). Furthermore, the country's stock of total external debt--which includes foreign debt of the public sector, commercial banks, and the private sector--reached 27.3 billion dollars by the end of 1976, from 7.9 billion in 1971.

During 1976, a year of presidential elections in Mexico, capital flight rose substantially, reaching levels not observed in this country during the previous fifteen years. This capital flight appeared to be supported by borrowing abroad and by the depletion of Mexico's international reserves held at the central bank (see Table 2.4). On the eve of the last presidential address--on August 31 of 1976--President Echeverría announced that the exchange rate would be depreciated from 12.50 Pesos per U.S. Dollar to 20.50 Pesos per U.S. Dollar effective September 1, 1976. That increase in the exchange rate was equivalent to a 64 percent nominal depreciation. The nominal exchange rate had been maintained fixed at 12.50 Pesos per Dollar during 22 years since April of 1954. By mid-September 1976, as capital flight continued at a faster rate, Mexico signed a three-year stand-by agreement with the International

Table 2.4. Mexico's Balance of Payments in Millions of Dollars

Year	Current Account	Net Flow of Total External Debt	Direct Foreign Investment	Special Drawing Rights	Other Capital Flows and Errors and Omissions	Change in International Reserves
1960	-419.7		-48.6	0.0		-8.6
1961	-343.7	169.6	94.1	0.0	58.5	-21.5
1962	-249.6	190.3	90.3	0.0	-14.1	16.9
1963	-226.1	198.7	81.4	0.0	55.7	109.7
1964	-444.7	518.0	112.1	0.0	-153.8	31.6
1965	-442.9	171.9	152.6	0.0	97.4	-21.0
1966	-477.8	382.7	90.7	0.0	10.5	6.1
1967	-603.0	584.6	6.0	0.0	52.2	39.8
1968	-775.4	443.1	107.7	0.0	273.6	49.0
1969	-708.4	520.2	181.4	0.0	54.7	47.9
1970	-1187.9	474.8	184.6	45.4	585.2	102.1
1971	-928.9	487.8	173.0	39.6	428.5	200.0
1972	-1005.7	415.9	146.2	39.2	669.1	264.7
1973	-1528.8	2488.0	199.5	0.0	-1036.4	122.3
1974	-3226.0	4031.7	288.8	0.0	-1057.6	36.9
1975	-4442.6	5865.9	168.2	0.0	-1426.4	165.1
1976	-3683.3	6680.9	199.8	0.0	-4201.4	-1004.0
1977	-1596.4	3287.3	326.0	0.0	-1359.8	657.1
1978	-2693.0	2988.8	364.5	0.0	-226.2	434.1
1979	-4870.5	6634.7	742.6	70.0	-2157.9	418.9
1980	-10739.7	10515.5	2145.5	73.5	-976.3	1018.5
1981	-16052.1	23283.3	3835.8	69.6	-10124.4	1012.2
1982	-6221.0	12676.0	1657.5	0.0	-11297.3	-3184.8
1983	5418.4	3095.0	460.5	0.0	-5873.1	3100.8
1984	4238.5	6601.0	391.1	0.0	-8029.7	3200.9
1985	713.5	138.0	490.5	0.0	-3670.4	-2328.4
1986	-1644.2	4425.0	1521.9	0.0	-3317.7	985.0
1987	3752.5	6479.0	3247.6	0.0	-6554.7	6924.4
1988	-2520.6	-7086.0	2594.6	0.0	-115.0	-7127.0
1989	-6050.6	-5270.0	3036.9	0.0	8555.2	271.5
1990	-7113.9	4621.0	2633.2	0.0	3274.0	3414.3
1991	-13282.8	4390.0	4761.5	0.0	11952.8	7821.5

Source: Banco de México, Indicadores Económicos; and Annual Reports.

Monetary Fund (IMF).

The year 1977, the first year of the new administration of López Portillo, has been characterized as a period of adjustment, in part to slow down the economy and in part to comply with the IMF stand-by agreement signed a year earlier. At the end of 1977, the growth in GDP (3.4 percent) was the lowest since the beginning of the decade; inflation also declined from 27.2 percent to 20.7 percent; and the current account balance of -1.6 billion dollars was about half of its 1976 level of -3.7 billion dollars (see Tables 2.3 and 2.4).

This adjustment year seemed to be the result of the implementation of less expansionary fiscal and monetary policies by the Mexican authorities. In 1977, the public sector deficit relative to GDP of -6.3 percent was lower than the -9.1 figure of the previous year. Also, the growth rate in the money supply (currency plus demand deposits) declined from 35.7 percent in 1976 to 26.3 percent in 1977 (see Table 2.3). These restrictive monetary and fiscal policies would not last much longer as the Mexican government announced that Mexico's oil reserves were much larger than previously estimated. The "oil-boom" years are discussed next.

Oil boom, 1978-1982

By 1978, the second year of the new administration of López Portillo, the three-year adjustment program supported by the stand-by agreement with the International Monetary Fund was abandoned. The Mexican authorities had decided to change their policies due in part to the new discoveries of crude oil and to their plans to export it (Zedillo (1986)). Once again, the Mexican authorities undertook expansionary fiscal and monetary policies that seemed to have brought about a four-year oil boom that began in 1978 and ended in 1981.

Oil reserves, including crude oil and natural gas, proved to be much larger than previously estimated. Also, they were continuously revised upwards. As Table 2.5 shows, oil reserves that were only 6.3 billion barrels in 1975, suddenly increased to 11.2 billion barrels by end-1976 and to 16.0 billion barrels by end-1977. By 1982, the last year of the López Portillo administration, total oil and natural gas reserves stood at 72.0 billion barrels. Interestingly enough, as illustrated by Table 2.5, this newly found oil wealth of Mexico coincided with increases in world prices that more than doubled from 1975 to 1982 in nominal terms.

As oil reserves continued to increase so did oil production. As shown in Table 2.5, in 1975 daily crude oil production stood at 0.7 million barrels while in 1982 it

Table 2.5. Mexico's Oil Reserves, Crude Production and Exports, and World Price of Oil

Year	Oil and Natural Gas Reserves[a]	Crude Oil[b] Production	Crude Oil[b] Exports	Oil and Natural Gas Exports: Millions of Dollars	Oil and Natural Gas Exports: %	Oil and Natural Gas Exports: % of Merchandise Exports	Price of Oil, Dollars Per Barrel: Nominal	Price of Oil, Dollars Per Barrel: %
1960	4.8	0.271	0.003	17.0	-	2.3	-	-
1961	5.0	0.293	0.018	20.0	17.7	2.5	1.73	-
1962	5.0	0.306	0.020	23.1	15.7	2.6	1.73	0.0
1963	5.2	0.315	0.020	37.1	60.6	4.0	1.73	0.0
1964	5.2	0.316	0.021	36.1	-2.7	3.6	1.73	0.0
1965	5.1	0.323	0.013	39.6	9.7	3.6	1.73	0.0
1966	5.4	0.332	-	42.1	6.2	3.6	1.73	0.0
1967	5.5	0.365	-	45.2	7.4	4.1	1.73	0.0
1968	5.5	0.389	-	40.8	-9.8	3.5	1.73	0.0
1969	5.6	0.411	-	40.3	-1.3	3.0	1.73	0.0
1970	5.6	0.429	-	38.0	-5.6	2.9	1.73	0.0
1971	5.4	0.427	-	31.0	-18.4	2.3	2.21	27.7
1972	5.4	0.441	-	21.0	-32.3	1.3	2.37	7.2
1973	5.4	0.452	-	25.0	19.0	1.2	3.56	50.2
1974	5.8	0.575	0.016	123.0	392.0	4.3	10.24	187.6
1975	6.3	0.717	0.094	460.0	274.0	15.0	10.89	6.3
1976	11.2	0.801	0.094	562.9	22.4	15.4	11.28	3.6
1977	16.0	0.981	0.202	1037.3	84.3	22.3	12.42	10.1
1978	40.2	1.213	0.365	1863.2	79.6	30.7	12.42	0.0
1979	45.8	1.471	0.533	3975.0	113.3	45.1	16.77	35.0
1980	60.0	1.941	0.830	10441.3	162.7	67.3	27.60	64.6
1981	72.0	2.312	1.098	14574.0	39.6	72.5	32.03	16.1
1982	72.0	2.746	1.492	16454.1	12.9	77.5	32.03	0.0
1983	72.5	2.666	1.537	16017.2	-2.7	71.8	28.05	-12.4
1984	71.8	2.685	1.529	16337.6	2.0	67.5	27.03	-3.6
1985	69.2	2.630	1.434	14529.8	-11.1	67.1	26.44	-2.2
1986	70.0	2.428	1.290	6104.1	-58.0	38.1	11.60	-56.1
1987	69.0	2.541	1.345	8468.9	38.7	41.0	16.65	43.5
1988	67.6	2.506	1.307	6507.8	-23.2	31.6	12.65	-24.0
1989	66.5	2.513	1.278	7842.8	20.5	34.3	15.02	18.8
1990	65.5	2.548	1.277	10103.7	28.8	37.6	19.58	30.3
1991	65.0	2.676	1.369	8166.4	-19.2	30.1	15.83	-19.2

Source: PEMEX, Memorias de Labores; Banco de México, The Mexican Economy, 1993.

[a] Billions of Barrels, end-of-period.

[b] Millions of Barrels, Daily Average.

reached 2.7 million barrels. Moreover, crude oil exports followed such upward trend in production. In 1975, crude oil exports were about 0.1 million barrels a day, while in 1982 they were 1.5 million barrels a day.

During the years 1978 to 1981 of the López Portillo administration, commonly referred to as the four "oil-boom" years, GDP averaged 9.2 percent. Furthermore, total gross fixed investment in real terms not only increased at an average rate of 16.7 percent during the period 1978-1981, but its participation in GDP also increased by 26.5 percent during the same years. Moreover, real gross domestic investment of the public sector was very dynamic during the four-year period averaging about 22.0 percent. In addition, its participation in Mexico's GDP increased to an average of 10.5 percent in the same four years. That average was larger than the average of 7.9 percent of the previous six years of the Echeverría administration, and also larger than the average of 6.5 percent of the decade 1960-1970.

Moreover, Table 2.3 shows that the four "oil-boom" years brought about not only higher economic growth but also higher inflation rates. During that period, inflation increased from 16.2 percent in 1978 to 28.7 percent in 1981. The "public-expenditure-led" growth model applied to Mexico in Echeverría's administration was being implemented again by the López Portillo administration, only this time with greater public sector spending. According to Table 2.3, the overall public sector deficit or financial requirements of the public sector as a proportion of GDP more than doubled during those four years, from -6.2 percent in 1978 to -14.1 in 1981. According to Zedillo (1986), the López Portillo administration argued that the government would finance its heavy spending in a non-inflationary fashion with the newly discovered oil wealth. Furthermore, the Mexican authorities announced that to avoid the problems of the earlier years, a new set of policies with new policy instruments would be implemented as well. To that extent, a financial reform that aimed at maintaining an interest rate policy with flexible interest rates that reflected domestic and international market conditions was implemented in 1978. The chief instruments of this reform were the newly introduced government securities known as Treasury Certificates (CETES). The idea behind the introduction of CETES was to use these government securities as an open market operations tool to primarily finance the public sector deficits. Another reform consisted of implementing a value-added tax during the same year. In addition, the Mexican authorities also attempted to eliminate some restrictions on imports during the period 1978-1980.

Furthermore, Mexico's money supply during those four years also revealed the effect expansionary policies and of larger public sector deficits. From Table 2.3 we can infer that money supply (currency plus demand deposits) grew at a four-year average of 33.0 percent during the period 1978-1981. That growth average was higher than the previous administration's 1971-1976 average of 22.1 percent.

Finally, Table 2.4 shows that during the oil-boom years the current account continued to deteriorate, from a deficit of 2.7 billion dollars in 1978 to a deficit of 16.1 billion dollars in 1981. The deterioration of Mexico's current account during those years took place in spite of the very impressive performance of the oil exporting sector. Crude oil and natural gas exports increased from 1.9 billion dollars in 1978 to 14.6 billion dollars in 1981. Also, as a share of total merchandise exports, oil exports also increased from 30.7 percent in 1978 to 72.5 percent in 1981 (see Table 2.5).

By year-end 1982, the last year of the López Portillo Administration, Mexico's GDP had fallen 0.6 percent, inflation had reached 98.9 percent, money supply had grown 54.1 percent and the deficit of the public sector had reached -16.9 percent of GDP (see Table 2.3). Also, as Table 2.4 suggests, capital flight had become a serious problem in 1981 and in 1982. The Figures of the Other Capital Flows and Errors and Omissions item of Table 2.4 show that Mexico experienced capital flight of about -10.1

billion dollars and -11.3 billion dollars during 1981 and 1982 respectively. Moreover, it would appear that in the early 1980s, the combination of the current account deficits, the capital flight, and the depletion of international reserves held at the central bank during the same period, were accompanied by a significant increase in Mexico's external debt. By year-end 1982 the stock of total external debt stood at 86.7 billion dollars, or about 48 percent of GDP, compared to 27.3 billion dollars in 1976, equivalent to 31 percent of GDP (see Table 2.6).

Moreover, by year-end 1982, international reserves at the central bank fell by 3.2 billion dollars. At that point, external lending became increasingly difficult to obtain, particularly during the first half of 1982.[4] Facing this severe situation, the Mexican authorities undertook some drastic measures designed to slow down the flight of capital beginning with the introduction of a dual exchange rate regime on August 5, 1982. During the second week of August 1982, the Mexican authorities decided to make all dollar-denominated deposits in the Mexican banking system payable only in domestic currency. At the same time, all commercial banks were instructed to suspend all transactions

[4]Ernesto Cedillo (1986) noted that by mid-1982 "Mexico's creditworthiness had completely deteriorated" as only 75 international banks out of 650 that were invited to subscribe a new emergency loan agreed to new lending.

Table 2.6. Stock of Mexico's External Debt End-of-Period

Year	Millions of Dollars: Total External Debt	Millions of Dollars: Public External Debt	Total Debt as a % of: GDP	Total Debt as a % of: Current Account Income	Total Debt as a % of: Merchandise Exports	Public Debt as a % of: GDP	Public Debt as a % of: Current Account	Public Debt as a % of: Merchandise Exports
1960	3722.3	3250.0	30.9	257.8	503.9	27.0	225.1	440.0
1961	3891.9	3440.0	29.8	258.0	484.4	26.3	228.0	428.1
1962	4082.2	3550.0	29.0	251.0	450.3	25.2	218.3	391.6
1963	4280.9	3740.0	27.3	237.3	453.4	23.8	207.3	396.1
1964	4798.9	4130.0	25.9	248.6	467.7	22.3	214.0	402.5
1965	4970.8	4180.0	24.6	241.0	441.3	20.7	202.7	371.1
1966	5353.5	4420.0	23.9	238.8	457.6	19.7	197.2	377.8
1967	5938.1	4960.0	24.2	257.1	538.4	20.2	214.7	449.7
1968	6381.2	5330.0	23.5	251.5	547.7	19.6	210.1	457.5
1969	6901.4	5812.1	23.0	241.9	514.3	19.4	203.7	433.2
1970	7376.2	6255.5	20.7	226.6	572.0	17.6	192.2	485.1
1971	7864.0	6666.7	20.0	222.7	575.9	17.0	188.8	488.2
1972	8279.9	6820.9	18.3	193.4	496.9	15.1	159.4	409.3
1973	10767.9	8448.8	19.5	199.2	519.8	15.3	156.3	407.8
1974	14799.6	11373.8	20.5	216.4	518.7	15.8	166.3	398.6
1975	20665.5	15705.1	23.5	289.6	674.8	17.8	220.1	512.8
1976	27346.4	20846.4	30.7	330.4	748.1	23.4	251.9	570.3
1977	30633.7	23833.7	37.4	333.8	658.8	29.1	259.7	512.6
1978	33622.5	26422.5	32.7	288.5	554.5	25.7	226.7	435.8
1979	40257.2	29757.2	29.8	247.5	456.5	22.1	183.0	337.5
1980	50772.7	33872.7	26.0	226.6	327.3	17.4	151.2	218.4
1981	74056.0	52156.0	29.6	264.4	368.4	20.8	186.2	259.5
1982	86732.0	58874.0	48.1	309.7	408.5	32.6	210.2	277.3
1983	89827.0	62556.0	60.3	310.3	402.6	42.0	216.1	280.4
1984	96428.0	69378.0	54.9	293.1	398.5	39.5	210.9	286.7
1985	96566.0	72080.0	52.3	305.9	445.7	39.0	228.3	332.7
1986	100990.9	75351.0	77.5	400.8	625.0	57.8	299.0	466.3
1987	107469.0	81407.0	76.3	341.9	524.4	57.8	259.0	397.2
1988	100914.3	81003.0	58.9	297.8	491.2	47.3	239.0	394.3
1989	96448.2	76059.0	47.1	253.2	422.2	37.2	199.7	333.0
1990	101859.3	77770.0	42.2	226.0	379.5	32.2	172.6	289.8
1991	104827.8	79988.0	37.1	228.9	386.5	28.3	174.7	294.9

Source: Banco de México, Annual Reports, and The Mexican Economy 1993.

in foreign currency. Furthermore, on August 20, the Secretary of Finance, Jesus Silva Herzog, requested a three-month moratorium on payments of principal of Mexico's external debt, as well as the formation of an "advisory group" of creditors to negotiate the restructuring of Mexico's foreign debt. Finally, on September 1, 1982, President López Portillo in his last presidential address announced that all private commercial banks were being nationalized and that foreign exchange controls had been implemented.

For the most part, the Mexican "oil-boom" years were characterized by heavy government spending in a way similar to that of the "public-expentiture-led growth model" of the previous administration but with government spending that was much heavier as it relied on future revenues from oil exports and on heavy external borrowing. Moreover, the combination of fiscal deficits of unprecedented proportions, the increasingly larger capital flight that reached historical levels, together with external borrowing coming to a halt, resulted in one of the most severe economic crises in Mexico's history.

Fiscal correction and stabilization, 1983-1991

During the last four months of 1982, Mexico paid only the interest due on its foreign external debt and a very small percentage of its principal. As for its private external debt all payments had been suspended. Furthermore, the incoming administration of Miguel De La Madrid, that took office in December of 1982, faced an economy with heavy government spending, increasing government intervention and large barriers to foreign trade.

As the OECD Economic Survey of Mexico indicates, (OECD 1992, pp. 25) the main economic distortions and imbalances the Mexican economy experienced at the outset of 1983 consisted of: (1) high fiscal deficits together with a large number of loss-making enterprises owned by the public sector; (2) an inflation rate that reached an annual rate of almost 100 percent by the end of 1982; (3) large current account deficits that developed in spite of significant increases in oil exports making the export sector largely dependent on oil; (4) foreign banks unwilling to extend further credits; (5) large transfer of resources abroad to service the external debt under conditions of historically high interest rates; (6) an internal price structure heavily distorted by direct government intervention and controls; (7) a mostly inefficient, under-productive and low-quality industry supplying a highly protected domestic market, with few incentives to export; and (8) a private sector hostile to the government and doubtful of its ability to manage the economy.

To address these issues, the De La Madrid administration undertook a three-year adjustment program called "Immediate Programme for Economic Reordering" (PIRE in its Spanish acronym), that covered the period from 1983 to 1985. The main objectives of the PIRE were three: to address the external debt crisis, to stabilize the economy and to restore the private sector's confidence in the Mexican government. To achieve these objectives, the PIRE relied on the following: first, to correct the public sector imbalance; second, to replace the exchange rate controls; third, to restructure Mexico's external debt; and fourth, to ratify the stand-by agreement with the International Monetary Fund agreed upon in mid-November of 1982.

The Mexican authorities established that at the center of the PIRE was the reduction of the public sector imbalance and decided to set targets for the public sector's deficit as a percentage of GDP of 8.5 percent, 4.5 percent and 3.5 percent for 1983, 1984 and 1985 respectively. In addition, the authorities expected to reduce the inflation rate to 40 percent, 30 percent and 18 percent during the same years. Next, the authorities expected the growth rates in Mexico's GDP during the years 1983, 1984 and 1985 to be 0 percent, 3 percent and 6 percent, respectively (Lustig (1992)).

To achieve the targets set for the public sector deficits, the Mexican authorities followed a tight fiscal policy. On the one hand, reducing public spending in 1983 entailed across-the-board cuts in real current and capital expenditures. On average, the federal government current expenditures in wages and salaries, goods and services, and capital expenditures decreased by almost 25 percent in real terms during 1983 (see Table 2.7).

On the other hand, revenue enhancing measures consisted of increasing both indirect and direct taxes as well as raising prices of some goods produced by public enterprises such as the prices of gasoline and electricity. As Table 2.7 shows, during 1983 federal government revenues from value added tax (VAT) rose by 31.4 percent, while gasoline tax revenues increased by 25.4 percent in real terms.

As for the second element of the PIRE, the new administration of De La Madrid decided to devaluate the controlled exchange rate by about 90 percent in December 1982 and to eliminate the exchange rate controls that were imposed by the outgoing López Portillo's administration on September 1, 1982, while maintaining the dual exchange rate system. The dual exchange rate system consisted of a controlled rate and a free rate. The controlled rate was to be used in business transactions involving all current account transactions (except factor payments) and foreign related capital flows. This rate followed a crawling-peg rule with a rate of depreciation of 13 Peso-cents per day.

Table 2.7. Mexico's Federal Government Revenues and Expenditures
Annual Percentage Change in Constant Prices of 1980

Concept	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Total Revenue	8.6	1.7	9.0	-1.7	2.5	-8.7	8.7	-0.4	9.9	1.1	24.6
Tax Revenue	7.8	0.5	10.4	-0.6	1.9	-9.5	8.5	-1.4	3.6	3.3	4.4
Direct Taxes	10.6	0.1	8.0	-3.3	1.9	-21.6	17.3	-7.4	6.4	4.2	3.5
PEMEX	13.2	21.6	34.2	-8.3	2.4	-37.4	42.5	-33.7	6.7	12.4	-1.9
Income Tax	8.9	-14.8	-17.9	4.9	1.1	0.8	-4.9	27.5	6.2	-1.4	7.8
Indirect Taxes	3.0	1.2	14.9	4.1	1.9	9.8	-1.7	6.7	0.3	2.1	5.5
VAT	5.1	-15.2	31.4	9.2	-0.0	-2.7	4.8	12.2	-3.1	21.2	3.7
Excise taxes	4.1	74.6	27.0	-2.8	-1.4	23.1	-7.1	12.3	-7.4	-31.3	-8.6
Gasoline	-2.0	243.3	25.4	2.1	-3.9	27.2	-8.5	11.3	-12.4	-49.9	8.1
Other	7.5	-9.7	30.0	-11.8	3.8	15.2	-4.0	14.2	2.6	0.7	-22.8
Import Duties	20.8	-23.0	-48.1	8.1	36.6	20.5	-2.7	-40.7	72.1	28.6	29.2
Other Taxes	-39.0	-19.2	-3.1	2.1	-9.2	24.5	-17.5	25.5	5.3	1.8	33.5
Non-Tax Revenue	22.4	22.0	-9.4	-20.7	14.1	7.1	13.3	14.3	90.5	-14.5	194.2
Total Expenditure	29.6	25.6	-9.8	-3.7	3.9	14.5	9.7	-14.3	-10.6	-8.3	-12.4
Current Expenditure	23.2	44.7	-6.6	-2.2	1.3	20.8	10.5	-11.4	-11.8	-13.0	-12.0
Wages and Salaries	12.3	10.2	-23.7	8.3	-1.1	-7.4	5.9	-11.7	10.4	-6.2	18.3
Goods and Services	53.4	20.0	-25.9	27.3	9.7	32.8	-30.5	8.8	8.4	-2.4	37.6
Interest	79.3	218.2	-6.0	-14.9	24.6	52.5	28.9	-13.7	-19.6	-22.3	-40.3
Tranfers	1.9	8.4	3.9	-16.8	3.6	-11.5	-19.1	-12.9	-8.4	-16.8	24.2
Other	35.9	-2.3	-0.8	35.0	-33.0	5.8	-13.9	-0.2	-0.9	18.2	7.6
Capital Expenditure	48.9	-22.5	-24.8	-12.1	20.3	-19.8	3.7	-39.1	5.2	42.4	-15.0
Investment	3.9	0.2	-39.8	-3.9	9.4	9.8	-9.4	-40.1	5.1	52.4	19.5
Capital Transfers	87.5	-36.3	-13.3	-16.8	27.2	-18.7	15.4	-41.1	5.5	35.3	-33.0
Other	24.3	3.1	-32.7	-7.0	14.2	-74.6	-52.1	38.4	2.4	78.7	-9.1

Source: Banco de México, Indicadores Económicos and The Mexican Economy 1992.

The free market exchange rate was to be used in all remaining transactions (Zedillo (1988), and Banco de Mexico (1984)).

The results of the PIRE turned out to be encouraging. By year-end 1983 the target set for the public sector deficit relative to GDP of 8.5 percent was practically achieved, however, bringing the economy to a negative growth rate of 4.2 percent (see Table 2.3 and Figure 2.1). During the period 1984-85 the fiscal deficits decreased to about half the level of 1982. In addition, economic growth resumed to an average rate of 3 percent while inflation fell a few percentage points during the same period (see Table 2.3 and Figures 2.1 and 2.2). In spite of major earthquakes in September 1985, that caused several billion dollars in damage to Mexico City, Mexico's outlook began to look promising--however very dependent on oil exports.

The fall in the world price of oil that started in late 1985 further exacerbated during 1986. As Table 2.5 shows, by year-end 1986 Mexico's oil and natural gas exports had fallen by 58.0 percent from the previous year. Furthermore, the loss in foreign exchange earnings from Mexico's oil exports in that year amounted to about 8.4 billion dollars. Its impact on the government's revenues was substantial. As illustrated by Table 2.7, the federal government tax revenues from PEMEX, the government's oil monopoly, fell by

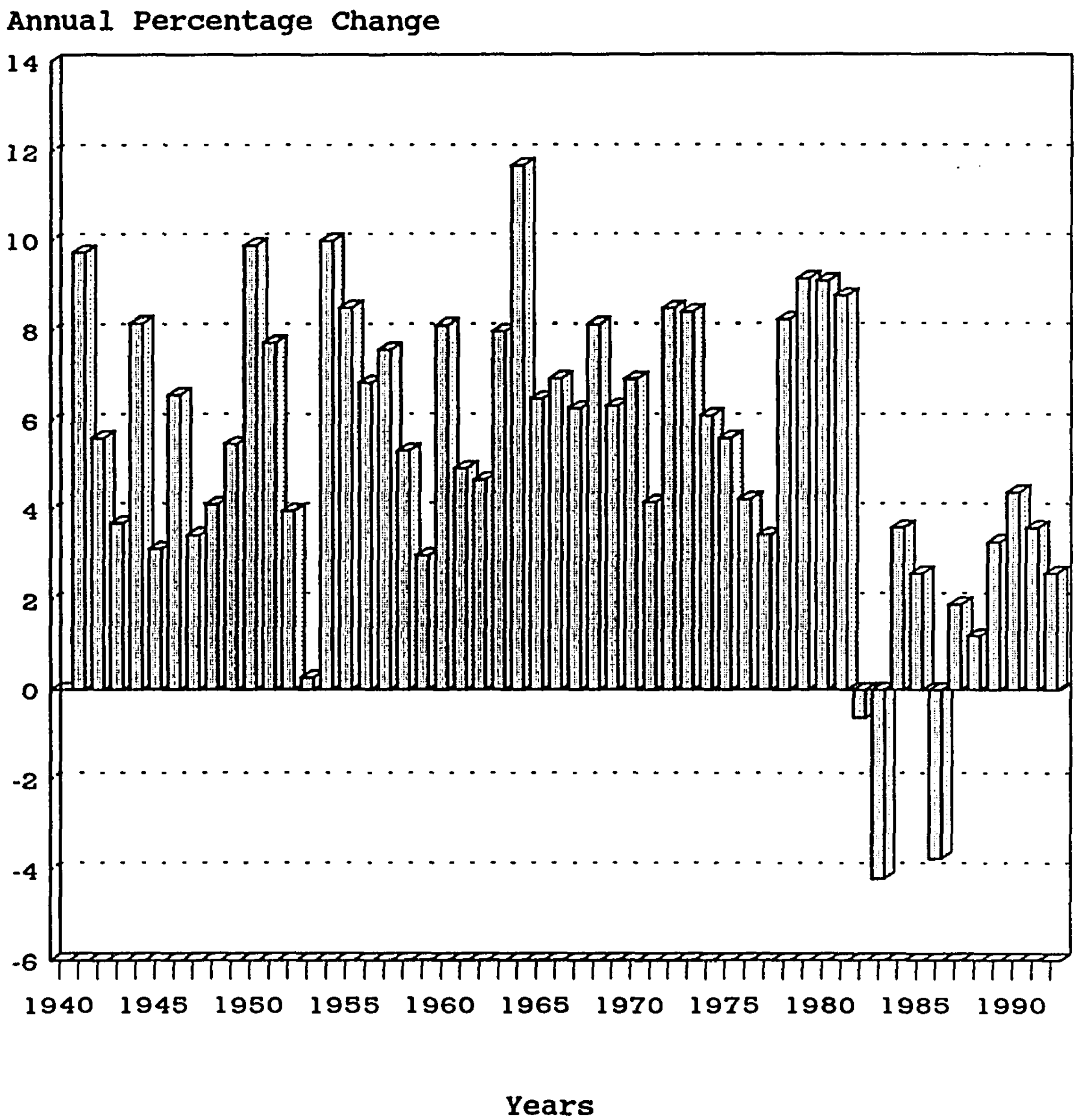

Figure 2.1. Mexico's Gross Domestic Product, 1940-1992
Source: Banco de Mexico, Annual Reports.

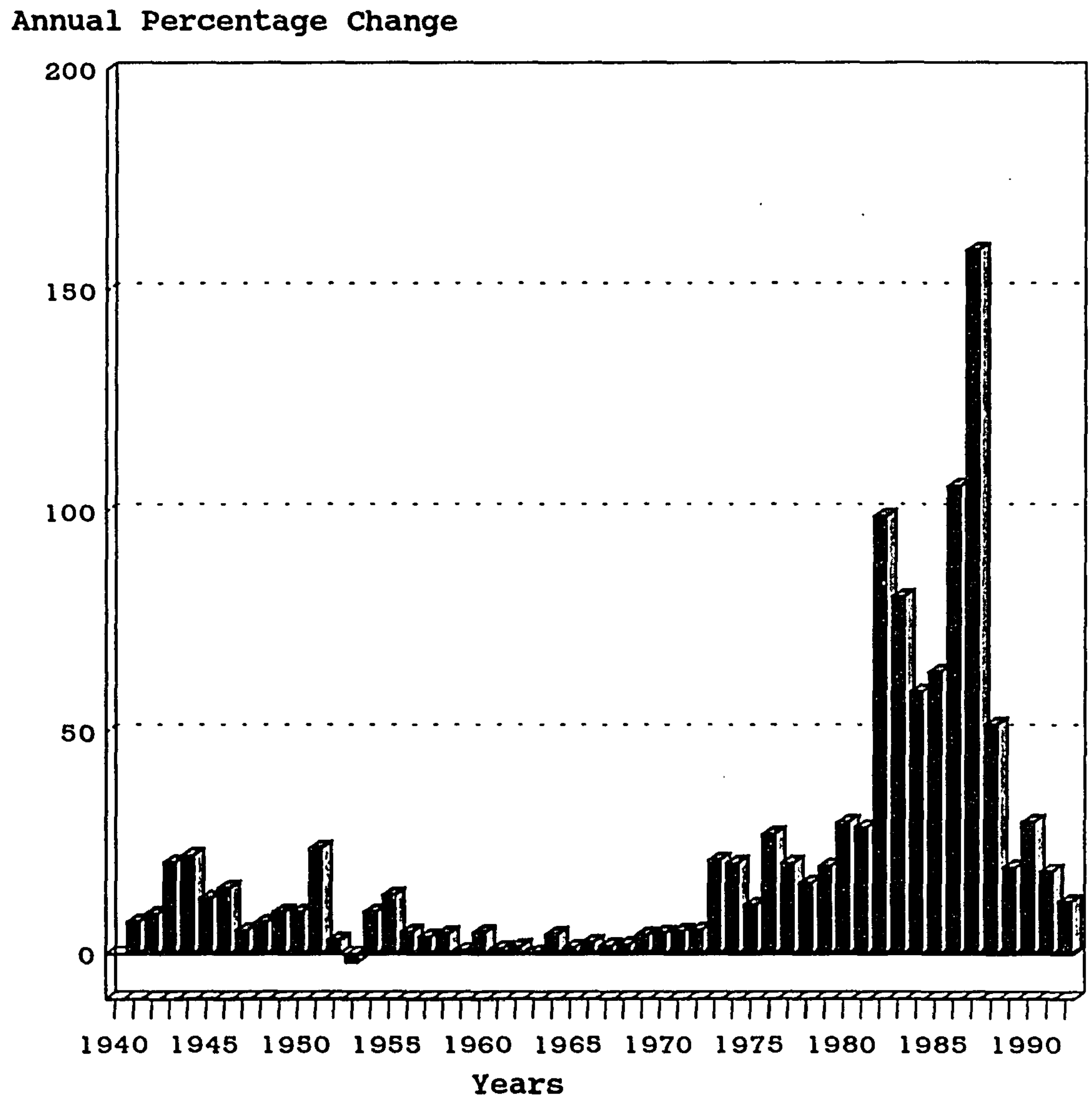

Figure 2.2. Mexico's Rate of Inflation, 1940-1992
Source: Banco de Mexico, Annual Reports.

37.4 percent in 1986.

The Mexican authorities reacted to this oil price shock by tightening fiscal policy which meant, once again, increasing fiscal revenues while decreasing fiscal expenditures in real terms. To raise real fiscal revenues, the authorities increased domestic petroleum prices and excise taxes which rose by about 23.1 percent. On the real expenditures side, tight fiscal policy meant to reduce the federal government's real capital expenditures by 19.8 percent in 1986 (see Table 2.7). In spite of those tightening measures the public sector's deficit relative to GDP reached -15.9 percent in that year (see Table 2.3).

Another measure that the Mexican authorities took as a result of the deterioration of the terms of trade, was to depreciate the Peso at a faster rate throughout 1986. Table 2.3 shows that real depreciation amounted to about 30 percent during that year. Furthermore, the current account balance turned negative during the same year after four years of positive balances. As Table 2.4 illustrates, the current account deficit reached -1.6 billion dollars in 1986, while capital flight (measured by the Other Capital Flows and Errors and Omissions item) continued at a rate of 3.3 billion dollars during that year.

After a 3.8 percent decline in GDP growth in 1986, the Mexican authorities allowed for some economic recovery by pursuing conservative policies rather than further fiscal tightening. By year-end 1987 economic growth recuperated slightly (1.7 percent), while inflation reached almost 160 percent (see Table 2.3 and Figures 2.1 and 2.2). At the same time, the Mexican Peso was depreciated in nominal terms by about 125 percent from 1986 to 1987. Also, Table 2.4 shows that the current account turned, once more, to a positive balance of 3.8 billion dollars while international reserves increased by almost 7.0 billion dollars.

Next, the Mexican economy that had been subject to two major shocks, the fall in oil price in 1985-86 and the earthquakes in 1985, was about to endure another shock. Perhaps as a widespread effect of the crisis in stock markets in most of the world during October 1987, the Mexican stock market also experienced a significant fall in that year as the stock market index showed a decline of 99.7 percent in November of 1987 (The Mexican Economy, 1992, p. 231).

At this point the Mexican authorities decided to accelerate the depreciation of the Peso, as international reserves holdings at the central bank started to fall and large amounts of capital flight were reported in Mexico's balance of payments accounts. This is illustrated in Table 2.4 by the errors and omissions data that show an outflow of 6.6 billion dollars in 1987. Furthermore, in December 1987 alone, the Peso was depreciated by 20 percent bringing about a sharp increase in the expected rate of inflation for the months ahead as the Peso depreciation was to be incorporated into Mexican Peso prices.

With that in mind, by the end of November 1987, the Mexican authorities declared that the government's highest priority was to reduce inflation and decided to undertake a stabilization program similar to the programs implemented by Argentina, Brazil and Israel. On December 16, 1987, a stabilization program, known as the Economic Solidarity Pact (or PSE in its Spanish acronym), was signed by representatives of the government, labor and the private sectors. The PSE's main objective was to reduce inflation without bringing about a severe recession in the Mexican economy that would result from implementing further restrictive macroeconomic policies. It comprised four elements: tightened fiscal policy, restrictive monetary policy, greater opening of the economy, and the commitment by all sectors of society to moderate price increases.

Prior to implementing the PSE the authorities decided to account for some distortions in the relative price system. Thus, a day before signing the PSE, the authorities increased prices and tariffs of public sector goods and services substantially. For instance, the price of gasoline increased by 85 percent, electricity by 89 percent, fertilizers by 82 percent and airfare by 26 percent, (The Mexican Economy 1989, p.8). Those price increases pushed upward the producer price index of public enterprises by 20 percent and 25 percent in November and December of 1987, respectively (see Figure 2.3). In addition, the minimum wage was raised by 15 percent on December 14 and by 20 percent on January 1, 1988.

Under the PSE, the authorities undertook the following measures. First, on December 15, 1987, the controlled exchange rate was depreciated by 22 percent. Next, official prices of imports (used as a reference for import duty) were eliminated together with most of the import permits. Finally, the maximum import tariffs were reduced from 40 percent to 20 percent (Mercado de Valores, Num. 22, November 15, 1991, p.15). These trade liberalization policies, the authorities argued, would eventually help bring down inflation as the domestic producers faced lower-priced imported goods.

The end-1987 price increases of goods produced by the public sector were thought of as an important step toward eliminating distortions in the relative price system as well as decreasing government spending. Had these prices not been increased, substantial government subsidies would have been needed, which in turn would have created pressures on

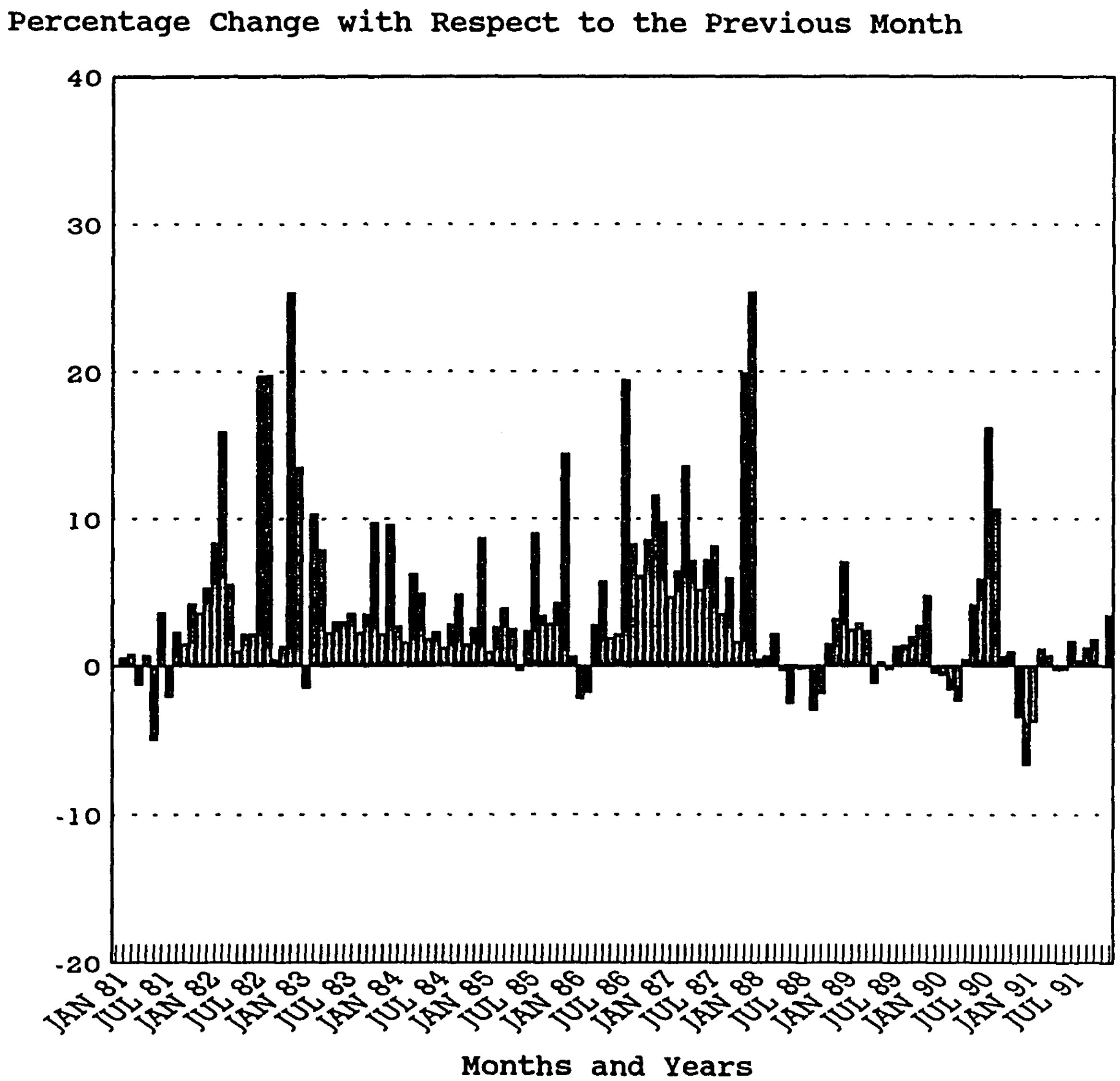

Figure 2.3. Mexico's Prices of Public Enterprises, 1981-1991
Source: Banco de Mexico, Indicadores Económicos

Mexico's public finances.[5]

During 1988, the PSE was signed again by representatives of the government, labor, and the private sector on five more occasions: on February 28, on March 27, on May 28, on August 14, and on October 16. On each occasion the PSE's four original guidelines were maintained as the central elements of the new strategy. To begin the new PSE strategy, on February 28, 1988, the exchange rate, minimum wage and energy prices were fixed throughout the rest of that year after increasing the prices of energy (85 percent), nominal exchange rate (22 percent) and minimum wage rate (35 percent).

Fiscal policy in Mexico during 1988 was kept on the restrictive side to comply with the PSE agreement. On the expenditure side, Table 2.7 shows that the federal government's total expenditure in real terms decreased by 14.3 percent in that year. Of that reduction, capital expenditures decreased the most (-39.1 percent) not withstanding the substantial decrease in current expenditures (-11.4 percent).

On the revenues side, Table 2.7 also shows that

[5]Francisco Gil Díaz (1984) estimated that if subsidies on oil, electricity and railway had been eliminated from 1965-1980, with the exception of 1975 and 1976, Mexico's public sector would have shown a budget surplus of as much as 3 percent of GDP throughout the period.

Mexico's federal total revenues in real terms diminished by about .4 percent in 1988, mainly as a result of a substantial fall in both taxes paid by PEMEX and tax collections from import duties. Direct taxes paid by PEMEX, the government's oil monopoly, decreased by 33.7 percent as a result of a reduction of its oil exports in that year (see Table 2.5). Moreover, Table 2.7 shows that revenues from import duties also decreased by a substantial amount (-40.7 percent), reflecting, in part, Mexico's new trade policy toward a more open economy. Overall, as Table 2.3 illustrates, the public sector borrowing requirements as a proportion of GDP declined to -12.4 percent in 1988 from -16.0 percent the previous year.

To comply with the PSE, Mexico's monetary policy was also kept on the restrictive side during 1988. On the one hand, domestic credit was restricted by the Central Bank through credit ceilings imposed on the Mexican financial system. Effective January 1988, total outstanding bank credit to the private sector was set at 90 percent of its average daily balance of December 1987. On February 1 of the same year, that ceiling was lowered even further to 85 percent. On the other hand, private demand for credit surged beginning May of 1988 as a result of a seasonal increase in output, increase in private investment and perhaps more importantly, increase in payments of the private external debt as world interest rates moved upwards (The Mexican Economy 1989, p. 16).

In spite of that excess demand for credit, Mexican interest rates were kept almost entirely fixed at an average of about 40 percent from May 1988 through November 1988. Not surprisingly, that excess demand for credit in Mexico's financial system was accompanied by the development of an informal credit market. This market, according to the central bank, grew steadily beginning in July 1988, and by November it had reached a considerable size. As the informal market grew in size and importance it began to lessen the effectiveness of the restrictive monetary policy adopted by the authorities under the PSE. In response, by late October and early November, the monetary authorities implemented several measures aimed at attracting resources back to the commercial banks of the formal sector. The idea was to allow commercial banks to subscribe highly competitive financial instruments so that financial resources voluntarily left the informal market of credit.

According to Banco de Mexico (The Mexican Economy 1989, p. 18), the relevant elements of that policy consisted of the following. First, commercial banks were authorized to subscribe bankers' acceptances and to grant guarantees on commercial paper without any limits of value and interest paid on such instruments. Consequently, interest rates and maturities of these instruments were freely determined by market conditions. Second, commercial banks were authorized to trade bankers' acceptances. Finally, liabilities resulting from bankers' acceptances and guarantees on commercial paper would be required to have a counterpart of no less than 30 percent in government securities or in interest bearing deposits at Banco de Mexico, a requirement known as the liquidity coefficient. Bankers' acceptances were not subject to other legal requirements applied to traditional instruments.

These measures appeared to have the desired effect of transferring funds from the informal market to the formal commercial banking system as suggested by the increase in the amount of bankers' acceptances relative to total deposits in real terms from 1.8 percent in September of 1988 to 48.7 percent in December of the same year. Moreover, as a result of this increase in bank deposits, commercial banks' credit to the private sector in real terms increased by 31.7 percent during the period September-December. That surge in the money supply did not conform to the tight monetary policy agreed upon under the PSE. To offset that expansion of domestic credit, the monetary authorities sold large quantities of government securities (CETES) to the public. Thus, government securities in the hands of the public in real terms increased by 46.7 percent from October to December 1988.

The new financial instruments introduced into the Mexican banking system, together with the credit policies of the October-November 1988 period, marked a turning point in monetary policy management in Mexico. They strengthened the role of open market operations as the main instrument of monetary policy and source of financing to the public sector.

As for the foreign sector, Table 2.4 shows a negative balance in Mexico's current account of -2.5 billion dollars during 1988, in contrast to the positive current account balance of 3.7 billion dollars in 1987. In addition, international reserves declined substantially at a rate of 7.1 billion dollars during the same year. These developments, as the OECD survey (p. 35) suggests, appeared to be the "result of the rapid increase in imports that followed the acceleration of trade liberalization, the high and increasing burden of servicing the foreign debt and the resumption of capital flight."

By year-end 1988, the last year of the De La Madrid administration, Mexico's inflation, had fallen to 51.7 percent from 159.2 percent of the year before. Interestingly enough, the 1988 fall in inflation was not accompanied by a severe drop in Mexico's economic growth as GDP showed an increase of 1.2 percent in 1988 (see Table 2.3

and Figures 2.1 and 2.2).

The deterioration of Mexico's balance of payments accounts together with the low growth of 1988, appeared to indicate to the authorities that it would be very difficult for Mexico to make substantial investments needed to achieve higher sustainable economic growth with lower inflation in the years to come, while at the same time transferring resources abroad at an average rate of 8.5 percent of GDP to service the external debt (see Table 2.8).

The incoming new administration of Salinas de Gortari considered Mexico's transfer of financial resources abroad a central issue to deal with in his economic agenda. On December 12, 1988, President Salinas announced the second phase of Mexico's stabilization program denominated Pact for Stability and Economic Growth (PECE), and instructed the Secretariat of Finance to initiate negotiations with the international financial community to renegotiate Mexico's external debt. The purpose of those negotiations was to reduce the transfer abroad of net financial sources.

The new PECE pact, that was designed and negotiated within the same framework as the previous PSE pact, attempted to consolidate the gains made in reducing inflation. Both pacts emphasized the government's commitment to a strict control of public finances and to restrictive monetary policy. Effective in January 1989, the

Table 2.8. Total Debt Service on Mexico's Total External Debt

Year	Millions of U.S. Dollars	As a Percentage of: GDP	Current Account Income	Merchandise Exports
1960	256.0	2.1	17.7	34.7
1961	261.8	2.0	17.4	32.6
1962	361.3	2.6	22.2	39.9
1963	335.5	2.1	18.6	35.5
1964	493.5	2.7	25.6	48.1
1965	498.6	2.5	24.2	44.3
1966	642.8	2.9	28.7	54.9
1967	684.2	2.8	29.6	62.0
1968	852.7	3.1	33.6	73.2
1969	854.5	2.8	29.9	63.7
1970	982.6	2.8	30.2	76.2
1971	953.6	2.4	27.0	69.8
1972	1082.9	2.4	25.3	65.0
1973	1544.2	2.8	28.6	74.5
1974	1661.3	2.3	24.3	58.2
1975	2291.7	2.6	32.1	74.8
1976	2880.0	3.2	34.8	78.8
1977	4268.9	5.2	46.5	91.8
1978	6835.9	6.6	58.7	112.7
1979	10995.2	8.2	67.6	124.7
1980	9851.1	5.1	44.0	63.5
1981	14251.3	5.7	50.9	70.9
1982	17422.2	9.7	62.2	82.1
1983	14592.3	9.8	50.4	65.4
1984	14068.5	8.0	42.8	58.1
1985	13017.2	7.0	41.2	60.1
1986	11505.6	8.8	45.7	71.2
1987	12798.9	9.1	40.7	62.5
1988	13901.3	8.1	41.0	67.7
1989	13313.5	6.5	35.0	58.3
1990	12843.7	5.3	28.5	47.9
1991	15297.2	5.4	33.4	56.4

Source: Banco de México, Annual Reports, and The Mexican Economy 1993.

PECE included some moderate increases in public goods prices, along with an increase in the minimum wage rate of 8 percent. In addition, the Mexican authorities changed the nominal exchange rate policy from a fixed rate to a crawling-peg rate that depreciated at a pre-announced rate of 1 Peso per day amounting to an annual nominal depreciation of about 16 percent.

The PECE has been renewed seven times since it was first signed in December 1988, with the last renewal in October 1993 to expire in December 1994. The adjustment program appears to have succeeded in bringing down Mexico's inflation while re-establishing its economic growth. The end-of-period consumer price index inflation fell to 19.7 percent in 1989, rose to 29.9 percent in 1990, fell to 18.8 percent in 1991 and dropped further to 11.2 percent in 1992. Moreover, Mexico's GDP has grown at positive rates of 3.3, 4.4, 3.6 and 2.6 percent respectively during those years.

The PECE has been accompanied by a significant reduction of net external resources transferred abroad since 1989 which resulted from a negotiated reduction of Mexico's external debt, the decline in international interest rates, and the surge of private capital inflows.

Mexico's external debt negotiations with the foreign financial community started in April 1989 and concluded in March 1990. According to Ortíz (1991), the savings that resulted from the Mexican external debt negotiations amounted to about 2.3 billion dollars in 1990 and to an average of 1.5 billion dollars per year during the period 1991-1994. Moreover, as Table 2.8 shows, the debt service on Mexico's total external debt as a percentage of GDP decreased from an average of 8.5 percent during the period 1983-1988 to an average of 5.7 percent in the period 1989-1991.

Falling foreign interest rates also helped to decrease Mexico's net transfers of financial resources abroad, as the London Interbank Offer Rate (LIBOR) fell to 6.0 percent by 1991. Consequently, as Table 2.9 shows, interest payments on Mexico's total external debt as a proportion of GDP fell to 3.8 percent in the period 1989-1991 from an average of 6.0 percent in the period 1983-1988. Finally, the surge in private capital flows to Mexico has increased significantly in the last few years. As Table 2.4 shows, other capital flows and errors and omissions shows a positive balance of 8.6 billion dollars in 1989, 3.3 billion in 1990 and 12.0 billion dollars in 1991. Next, let us discuss Mexico's trade policy and industrialization.

Table 2.9. Interest Payments on Mexico's External Debt

Year	Interest Payments in Millions U.S. Dollars		Interest Payments on Total External Debt as a Percentage of:			Interest Payments on Foreign Public Debt as a Percentage of:		
	Total External Debt	Foreign Public Debt	GDP	Current Account Income	Merchandise Exports	GDP	Current Account Income	Merchandise Exports
1960	67.4	36.2	0.6	4.7	9.1	0.3	2.5	4.9
1961	78.1	42.2	0.6	5.2	9.7	0.3	2.8	5.3
1962	93.4	64.3	0.7	5.7	10.3	0.5	4.0	7.1
1963	101.8	67.0	0.6	5.6	10.8	0.4	3.7	7.1
1964	114.8	74.6	0.6	5.9	11.2	0.4	3.9	7.3
1965	128.8	93.1	0.6	6.2	11.4	0.5	4.5	8.3
1966	171.3	125.6	0.8	7.6	14.6	0.6	5.6	10.7
1967	216.4	148.1	0.9	9.4	19.6	0.6	6.4	13.4
1968	280.4	199.3	1.0	11.1	24.1	0.7	7.9	17.1
1969	329.7	221.1	1.1	11.6	24.6	0.7	7.7	16.5
1970	417.0	290.3	1.2	12.8	32.3	0.8	8.9	22.5
1971	442.5	306.2	1.1	12.5	32.4	0.8	8.7	22.4
1972	481.5	321.4	1.1	11.2	28.9	0.7	7.5	19.3
1973	647.7	442.1	1.2	12.0	31.3	0.8	8.2	21.3
1974	973.3	707.1	1.4	14.2	34.1	1.0	10.3	24.8
1975	1436.6	1031.5	1.6	20.1	46.9	1.2	14.5	33.7
1976	1723.8	1318.7	1.9	20.8	47.2	1.5	15.9	36.1
1977	1973.9	1542.3	2.4	21.5	42.5	1.9	16.8	33.2
1978	2571.6	2023.1	2.5	22.1	42.4	2.0	17.4	33.4
1979	3709.3	2888.4	2.8	22.8	42.1	2.1	17.8	32.8
1980	6146.9	2397.7	3.2	27.4	39.6	1.2	10.7	15.5
1981	9485.3	3601.8	3.8	33.9	47.2	1.4	12.9	17.9
1982	12203.0	4921.3	6.8	43.6	57.5	2.7	17.6	23.2
1983	10102.9	4197.1	6.8	34.9	45.3	2.8	14.5	18.8
1984	11715.5	5063.2	6.7	35.6	48.4	2.9	15.4	20.9
1985	10155.9	4544.9	5.5	32.2	46.9	2.5	14.4	21.0
1986	8342.0	3682.9	6.4	33.1	51.6	2.8	14.6	22.8
1987	8096.7	3501.3	5.8	25.8	39.5	2.5	11.1	17.1
1988	8638.7	4365.2	5.0	25.5	42.0	2.5	12.9	21.2
1989	9277.6	4882.2	4.5	24.4	40.6	2.4	12.8	21.4
1990	9194.6	4559.4	3.8	20.4	34.3	1.9	10.1	17.0
1991	8387.7	4279.3	3.0	18.3	30.9	1.5	9.3	15.8

Source: Banco de México, Annual Reports, and The Mexican Economy 1993.

Trade Policy and Industrialization, 1957-1991

In 1948, the General Agreement on Tariffs and Trade (GATT) was established as a mechanism to negotiate and to monitor multilateral tariff reduction. At that point Mexico decided against becoming a member of GATT and participating in a freer trade system. Instead, Mexico adopted an inward-oriented growth model that appeared to be the result of both world and domestic conditions. As World War II increased the demand for primary products and reduced the supply of manufactured goods to developing countries, Mexican firms found it attractive to produce for the domestic market.

Internally, Mexico had been implementing nationalization policies that helped the government to increase its participation in the economy since the late 1930s. For instance, Lázaro Cárdenas, the president of Mexico from 1934-1940, nationalized foreign-owned oil companies and created Petróleos Mexicanos (PEMEX), the government-owned oil monopoly. López Mateos, Mexico's president from 1959-1964, nationalized the electric power industry and a large steel mill. By the time Mr. De La Madrid became Mexico's president (end of 1982), there were about 1,155 firms nationalized, including the nation's telegraph and telephone service, the banking system, airports, shipping firms, and others.

By the early 1950s, Mexico had adopted an industrialization policy denominated Import-Substitution Industrialization (ISI) that was based upon the thinking of both the Swedish economist Gunnar Myrdal (winner of the Nobel prize in 1974) and the Argentine economist Raúl Prebisch. The ISI arguments of Myrdal and Prebisch were so influential that economists from the Economic Commission for Latin America (ECLA) were recommending, during the 1950s and 1960s, that Latin American countries adopt such an ISI strategy for economic development.

The ISI strategy called for protection from foreign competition for domestic manufacturers, so that by keeping out foreign manufactured goods, domestically produced goods would be substituted for such goods, thus encouraging long-run growth. In other words, the ISI strategy assumed that the developed countries were net exporters of manufactured goods while the less developed countries were net exporters of primary goods. It also assumed that the income elasticity of demand was greater for manufactured goods than for primary goods. Thus as world income rose, the price of manufactured goods would increase relative to that of primary goods, which in turn would benefit the developed countries exporting manufactured goods.

Therefore, to avoid pervasive terms of trade changes against primary goods, the ISI strategy discouraged the

Table 2.10. Mexico's Exports of Merchandise, 1957-1991
Percentage of Total Merchandise Exports

Year	Merchandise Exports Total	Petroleum Total	Non- Petroleum Total	Primary Products	Extractive	Manufactures
1957	100.0	5.5	94.5	51.1	25.5	18.0
1958	100.0	3.6	96.4	58.0	18.8	19.6
1959	100.0	4.0	96.0	57.3	18.2	20.5
1960	100.0	2.3	97.7	52.7	19.0	26.0
1961	100.0	2.5	97.5	48.5	18.3	30.7
1962	100.0	2.6	97.4	52.4	16.3	28.8
1963	100.0	3.9	96.1	46.0	14.5	35.5
1964	100.0	3.5	96.5	47.7	14.2	34.5
1965	100.0	3.5	96.5	51.5	12.9	32.0
1966	100.0	3.6	96.4	52.4	13.1	30.9
1967	100.0	4.1	95.9	52.8	14.7	28.4
1968	100.0	3.5	96.5	51.2	15.3	30.1
1969	100.0	3.0	97.0	49.9	14.1	33.0
1970	100.0	2.9	97.1	47.7	13.8	35.5
1971	100.0	2.3	97.7	45.8	11.5	40.5
1972	100.0	1.3	98.7	46.9	10.9	41.0
1973	100.0	1.2	98.8	43.6	8.8	46.4
1974	100.0	4.3	95.7	28.1	12.0	55.6
1975	100.0	15.0	85.0	26.6	10.3	48.1
1976	100.0	15.4	84.6	32.1	5.7	46.7
1977	100.0	22.3	77.7	28.2	4.7	44.8
1978	100.0	30.7	69.3	24.8	3.5	41.0
1979	100.0	45.1	54.9	20.2	3.8	30.9
1980	100.0	67.3	32.7	9.8	3.3	19.5
1981	100.0	72.5	27.5	7.4	3.4	16.7
1982	100.0	77.5	22.5	5.8	2.4	14.3
1983	100.0	71.8	28.2	5.3	2.3	20.5
1984	100.0	67.5	32.5	6.0	2.2	24.2
1985	100.0	67.1	32.9	6.5	2.4	24.1
1986	100.0	37.8	62.2	14.2	3.2	44.8
1987	100.0	41.3	58.7	8.3	2.8	47.6
1988	100.0	31.7	68.3	9.1	3.2	56.0
1989	100.0	34.3	65.7	7.8	2.6	55.2
1990	100.0	37.6	62.4	8.1	2.3	52.0
1991	100.0	30.1	69.9	8.7	2.0	59.1

Source: Banco de México, Indicadores Económicos.

import of manufactured goods (intermediate and capital goods) while at the same time encouraged their production domestically.

During the early 1950s, Mexican policy makers, who found this ISI strategy very persuasive and counted on the government's control of key inputs such as oil and electricity, adopted a series of measures to promote Mexico's industrialization in accordance with the ISI strategy (Balassa (1983), Cardoso and Levy (1988), Zabludovsky (1989), and Ten Kate (1992)). At that time, both Mexico and ECLA agreed with the Myrdal-Prebisch argument that the income elasticity for primary goods was lower than the income elasticity for manufactured goods. In addition, Mexico was considered a net exporter of primary goods until 1973 (see Table 2.10).

To promote Mexico's inward industrialization in line with the ISI strategy, the authorities used trade policy as their chief policy tool. To protect the domestic industry from foreign goods, the Mexican authorities restricted imports by using three instruments: (a) an ad valorem import tariff system, (b) official minimum prices for customs valuations, and (c) a system of quantity restrictions either in the form of quotas or in the form of import licensing. Of all these three instruments, import

Table 2.11. Merchandise Imports and Import Licensing

Years	Merchandise Imports Millions of Dollars	Imports Licensing Millions of Dollars	Imports Licensing Percent of Merchandise Imports
1957	1155.2	405.5	35.1
1958	1128.7	479.8	42.5
1959	1006.6	434.8	43.2
1960	1186.4	448.4	37.8
1961	1138.6	612.5	53.8
1962	1143.0	600.0	52.5
1963	1239.7	787.2	63.5
1965	1559.6	935.7	60.0
1966	1602.0	993.2	62.0
1967	1736.8	1132.3	65.2
1968	1917.3	1234.7	64.4
1969	1988.8	1294.7	65.1
1970	2328.3	1590.2	68.3
1971	2255.5	1526.9	67.7
1972	2762.1	1831.2	66.3
1973	3892.5	2709.1	69.6
1974	6148.6	5041.8	82.0
1975	6699.4	4582.3	68.4
1976	6299.9	5695.1	90.4
1977	5704.5	5134.0	90.0
1978	7917.5	6041.1	76.3
1979	11979.7	8385.8	70.0
1980	18896.6	11337.9	60.0
1981	23948.4	20475.9	85.5
1982	14437.0	14437.0	100.0
1983	8550.9	8550.9	100.0
1984	11254.3	9341.1	83.0
1985	13212.2	4637.5	35.1
1986	12432.5	3356.8	27.0
1987	13305.5	3592.5	27.0
1988	20273.7	4298.0	21.2
1989	25437.9	4680.6	18.4
1990	31271.9	4378.1	14.0

Source: Jaime Zabludovsky (1988), Table 2, page 442, for 1957-1983; Pedro Aspe (1992), Table 1, page 323, for 1984-1990.

permits played the most important role (Cardoso and Levy (p. 355 (1988)).

During the period of "stabilizing development" (from 1957 to 1970), the percentage of imports controlled through import licensing increased steadily. As shown by Table 2.11, the percentage of merchandise imports subject to licensing increased from 35.1 percent in 1957 to 68.3 percent in 1970.

In addition, to continue with the authorities' protective measures, tariffs on competing import products were raised in 1956, in 1960 with the unification of customs classification, in 1962, and finally in 1965 (Balassa (1983)). Moreover, under the Law of Promotion of New and Necessary Industries, Balassa (1983) noted, Mexico's tariff system provided tariff exemptions on imports of machinery and imported inputs to new and necessary industries.

The effect of Mexico's tariff system on competing imported products and imported inputs has been reported by Arellano-Cadeno (1990). The various estimated effective rates of protection (ERP) for 1960, 1970 and 1980 are reported in Table 2.12. The ERP of Agriculture, Fishing and Forestry that was 3.0 percent in 1960 turned to a negative rate of -1.4 percent by 1970, perhaps as a result of lower protection and higher import prices (mostly fertilizer). This is important since Mexico was a net exporter of primary

Table 2.12. Effective Rates of Protection in Mexico

Economic Activity	Years		
	1960	1970	1980
Primary Products			
Agriculture, Fishing and Forestry	3.0	-1.4	18.0
Mining	-0.3	-12.4	-2.0
Intermidate Goods	13.2	16.8	43.0
Capital Goods and Durable Consumer Goods	64.6	77.2	128.0
Non-Durable Consumer Goods	13.2	31.6	9.0

Source: Rogelio Arellano-Cadena (1990), Table VI.2, p. 171.

goods during that period.

In addition, agriculture exports also faced a government's price policy that consisted of setting some domestic prices above world market levels. This price policy made it less attractive for Mexican producers to sell abroad since they received a higher price by selling in the domestic market rather than by selling abroad. That price policy was introduced in 1961 with the establishment of CONASUPO (Compañia Nacional de Subsistencias Populares).

Moreover, according to Table 2.12, Mining's ERP became more negative in 1970 with a rate of -12.4 percent compared to a rate of -0.3 percent in 1960; mostly as a result of taxes levied on the export sector. Furthermore, Mexican exports also faced a continuous real appreciation of the Peso as prices increased relatively more in Mexico than in the U.S., while the nominal exchange rate remained fixed as it had been since 1954.

Consequently, Mexico's tariff structure, its export tax policy, its export price policy, and its exchange rate regime strongly discriminated against Mexican exports during the "stabilizing development" or Import Substitution Industrialization. This combination of policies against exports has been commonly referred to as anti-export bias.

In contrast, the ERP on intermediate and capital goods

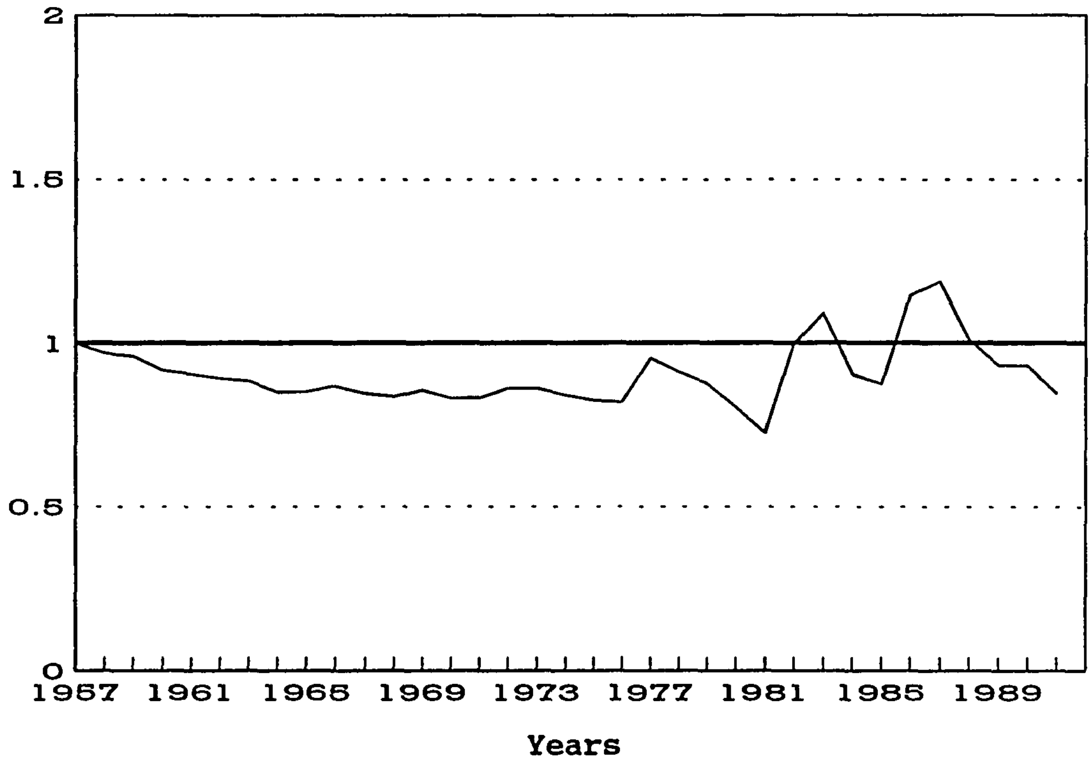

Figure 2.4. Mexico's Real Exchange Rate, 1957=1.0

Source: Banco de Mexico, Annual Reports. Real Exchange Rate = U.S. WPI*E/Mexico's WPI. WPI = Wholesale Price Index and E = Peso price of a U.S. Dollar.

of Table 2.12 show that the Mexican tariffs and subsidies system of the 1960s and 1970s provided strong incentives for domestic firms to direct their production towards Mexico's domestic market following the ISI strategy. Particularly, capital goods and durable consumer goods enjoyed an ERP of 64.6 percent in 1960 and 77.2 percent in 1970. In addition, the authorities supported the Mexican manufacturing sector by maintaining the nominal exchange rate fixed, resulting in a real appreciation of the Peso, that made imports of equipment and inputs less costly (see Figure 2.4). The real exchange rate is defined as the product of the Peso price of a U.S. dollar times the U.S. wholesale price index, divided by Mexico's wholesale price index. In other words, the real exchange rate $Q = (E * P^{us})/P^{mex}$ where E = the amount of Mexican Pesos per U.S. Dollar, P^{us} = U.S. wholesale price index, and P^{mex} = Mexico's wholesale price index.

In spite of the anti-export bias against Mexico's exporting sector, merchandise exports grew at an average annual rate of 4.9 percent during the period 1957-1970 (see Table 2.13). The positive growth in Mexico's merchandise exports, Arellano-Cadena (1990) noted, was due to two external factors: the U.S. tariff reduction on Mexican goods during the Kennedy administration and to the sustained economic growth of the U.S. economy during the 1960s. Nevertheless, Balassa (1983) found that Mexico's share of

Table 2.13. Mexico's Exports of Merchandise, 1957-1991
Percentage Change from Previous Year

Year	Merchandise Exports Total	Petroleum Total	Non- Petroleum Total	Non- Petroleum Primary Products	Non- Petroleum Extractive	Non- Petroleum Manufactures
1958	0.4	-33.6	2.4	14.1	-25.8	9.2
1959	2.0	14.4	1.5	0.7	-1.4	6.7
1960	2.2	-42.0	4.0	-6.1	6.9	29.7
1961	8.8	17.7	8.6	0.1	4.7	28.4
1962	12.8	15.7	12.7	21.8	0.3	5.9
1963	4.1	60.6	2.7	-8.5	-7.0	28.4
1964	8.7	-2.7	9.2	12.7	6.5	5.8
1965	9.7	9.7	9.7	18.5	-0.6	1.8
1966	3.9	6.2	3.8	5.5	5.8	0.1
1967	-5.7	7.4	-6.2	-4.9	5.4	-13.3
1968	5.6	-9.8	6.3	2.3	9.9	11.8
1969	15.2	-1.3	15.8	12.3	6.2	26.6
1970	-3.9	-5.6	-3.8	-8.1	-5.8	3.4
1971	5.9	-18.4	6.6	1.7	-12.0	20.6
1972	22.0	-32.3	23.3	25.0	15.3	23.7
1973	24.3	19.0	24.4	15.7	0.7	40.6
1974	37.7	392.0	33.4	-11.2	87.7	65.0
1975	7.3	274.0	-4.7	1.5	-7.9	-7.1
1976	19.4	22.4	18.8	44.2	-33.6	16.0
1977	27.2	84.3	16.8	11.7	3.7	21.9
1978	30.4	79.6	16.3	14.4	-1.9	19.3
1979	45.4	113.3	15.3	18.4	58.7	9.7
1980	75.9	162.7	4.7	-14.1	51.7	11.2
1981	29.6	39.6	9.0	-3.0	33.9	10.9
1982	5.6	12.9	-13.6	-16.8	-26.9	-9.5
1983	5.1	-2.7	31.8	-3.6	4.4	50.7
1984	8.4	2.0	24.8	22.9	2.9	27.8
1985	-10.5	-11.1	-9.2	-3.6	-5.3	-11.0
1986	-25.4	-58.0	40.9	63.4	-0.1	38.9
1987	26.8	38.7	19.6	-26.0	13.0	34.6
1988	0.3	-23.2	16.7	10.0	14.6	18.0
1989	11.2	20.5	6.8	-4.6	-8.4	9.6
1990	17.5	28.8	11.6	21.0	2.0	10.7
1991	1.0	-19.2	13.3	9.7	-11.4	14.9

Source: Banco de México, Indicadores Económicos.

the world markets of cotton, beef, coffee, silver, lead and copper fell during the same period. Also, as Table 2.10 shows, the share of primary goods in Mexico's merchandise exports fell from 51.1 percent in 1957 to 47.7 percent in 1970 while the manufactures share increased from 18.0 percent in 1957 to 35.5 percent in the same period.

During the Echeverría administration, the authorities decided to reduce the bias against exports by implementing a series of measures. In March 1971 the authorities introduced the certificates of tax deduction, CEDI, (Certificados de Devolución de Impuestos) to be applied to exports. Moreover, to assist the exporting sector, several institutions were created, e.g., FOMEX (Fondo para el Fomento de la Exportación de Productos Manufacturados) was created to increase the amount of credit available to the export sector; IMCE (Instituto Mexicano de Comercio Exterior) had as a chief objective to broaden Mexico's export markets by increasing its efforts in export promotion; and FONEI (Fondo Nacional de Equipamiento Industrial) had the objective of financing export-oriented and import-substituting projects. Additionally, in 1971 industries operating in the border areas that imported parts and components free of duty, assembled them and re-exported the final product mostly to the U.S., were formalized in Legislation. These industries that paid duty only on value added, commonly referred to as in-bond industries or maquiladoras, have steadily increased their share in Mexico's exports to the U.S.

During the early 1970s, the exporting sector improved, perhaps as a result of those policies against anti-export bias. As Table 2.13 shows, non-petroleum exports increased at a rate of 22 percent during the first four years of the Echeverría administration (1971-1974). However, by late 1975, as the U.S. economy went into a recession (see Table 2.14), and as the real exchange rate continued to appreciate (see Figure 2.4), Mexico's non-oil exports fell by almost 5.0 percent.

In the early years of the Echeverría administration, import permits were granted to support his nationalization policy that resulted in the creation of 108 new public enterprises. To that end, the authorities decreased import licensing in 1971 and 1972 (see Table 2.11). However, as the real exchange rate continued to appreciate and the current account worsened, import permits became the main policy instruments to correct balance of payments imbalances. By year-end 1976, the last year of the Echeverría administration, import licensing reached 90.4 percent. Notice, however, that increasing import licensing did not help the deterioration of the current account deficits (see Table 2.4).

Table 2.14. International Indicators[a]

Year	Percentage Change in U.S. GDP	Percentage Change in U.S. GDP Deflator	Nominal Interest Rate LIBOR	Real Interest Rate LIBOR
1961	2.7	0.9	4.4	3.4
1962	5.1	2.2	4.4	2.1
1963	4.1	1.3	4.0	2.6
1964	5.6	1.7	4.3	2.6
1965	5.6	2.7	4.8	2.0
1966	6.0	3.3	6.1	2.7
1967	2.6	3.1	5.5	2.3
1968	4.1	4.9	6.4	1.4
1969	2.7	5.0	9.8	4.5
1970	-0.0	5.3	8.5	3.0
1971	3.1	5.3	6.6	1.2
1972	4.8	5.0	5.4	0.4
1973	5.2	6.3	9.4	2.9
1974	-0.6	8.8	10.9	2.0
1975	-0.8	9.6	7.0	-2.4
1976	4.9	6.3	5.6	-0.6
1977	4.5	6.9	6.0	-0.8
1978	4.8	7.9	8.8	0.8
1979	2.5	8.7	12.1	3.1
1980	-0.5	9.4	14.2	4.4
1981	1.8	10.0	16.9	6.3
1982	-2.2	6.2	13.3	6.7
1983	3.9	4.1	9.7	5.4
1984	6.2	4.5	10.9	6.2
1985	3.2	3.6	8.4	4.6
1986	2.9	2.7	6.9	4.1
1987	3.1	3.2	7.2	3.9
1988	3.9	3.9	8.0	4.0
1989	2.5	4.5	9.3	4.6
1990	0.8	4.3	8.3	3.8
1991	-1.2	4.0	6.0	1.9

Source: International Financial Statistics, IMF; and Business Statistics, Department of Commerce.

[a] GDP = Gross Domestic Product, LIBOR = London Interbank Interest Rate.

Beginning in 1978, the new administration of López Portillo abandoned the restrictive monetary and fiscal policies adopted a year earlier. During the next four years, the 1978-1981 oil-boom years, the administration engaged in heavy spending, heavy external borrowing, and much more government involvement in the economy in which the acquisition of private sector firms played a key role. The nationalization efforts of López Portillo ended in 1982 with 520 new public enterprises created throughout his administration, including the commercial banking system that was nationalized in his last year in office.

To support this administration's nationalization efforts, the authorities adopted a modest trade liberalization program that consisted of lowering import licensing from 90.0 percent in 1977 to 60.0 percent in 1980. In addition, the authorities raised import tariffs in 1978, arguing that higher tariffs would allow firms to adjust to the new system and thus they would eventually be removed.

The policy of lowering import permits was abandoned in 1981 when the real exchange rate appreciated substantially (see Figure 2.4). By year-end 1982, the authorities raised import licensing to 100.0 percent of total merchandise imports. Also, the tariff increases of 1978 that were supposed to be temporary, were maintained and increased even further in 1981 and in 1982.

Looking at the protective effects of these policies, we find that the protection from foreign competition increased during this period. By 1980, the ERP on intermediate goods increased to 43.0 percent, a rate which was higher than that of 16.8 percent of 1970. Similarly, in 1980 the ERP on capital goods and durable consumer goods of 128.0 percent was also higher than that of 77.2 percent of 1970 (see Table 2.12).

It would appear that the modest attempt of trade liberalization undertaken by Mexico in 1978-1979 resulted in much higher protection than before, particularly by 1982. This time the agricultural sector also experienced protective policies as its ERP rose from -1.4 percent in 1970 to 18.0 percent in 1980, perhaps as a result of the introduction of the SAM (Sistema Agrícola Mexicano), the Mexican Foodstuffs Program in the late seventies. Under SAM some support prices of domestic crops were increased making it more attractive for farmers to produce for the domestic market rather than to export abroad. Also, continuing with policies against freer trade, López Portillo decided against GATT membership in March of 1980, which appeared to be followed by more protective measures that were implemented in 1981 and 1982.

Overall, Mexico's adoption of the Import-Substitution Industrialization (ISI) strategy for economic development along with the increasingly larger government intervention in the economy during the period 1957-1982, encouraged the creation of cost-inefficient industries that were unable to compete in foreign markets and had become increasingly dependent on imported inputs throughout this period. A measurement of imported inputs content was constructed by Arellano-Cadena (1990) using data from Mexico's various Input-Output tables. He defined an import-substitution coefficient as M_i * 100 / VA_i * M_i, where M_i is the imported inputs by industry i, and VA_i is its value added. According to Arellano's coefficient, a successful ISI strategy would imply a decrease in the value of that coefficient over time, as the requirements of imported inputs (M_i) in the production process also diminishes. In contrast to the ISI prediction, Mexico's economy became more and more dependant on imports. For instance, Table 2.15 illustrates the case in which with few exceptions, most sectors of the Mexican economy gradually increased the amount of imported inputs from 1970 to 1980. In particular, agriculture, mining, some manufactures (such as food, products of wood, paper, and chemicals), and metallurgy, all observed increasing values in their import substitution coefficients. Thus, Mexico's import-substitution model, (ISI strategy) that was supposed to eventually lead to lesser imports, had become an import-intensive model itself.

Table 2.15. Mexico's Coefficients of Import Substitution

Economic Activity	Years			
	1970	1975	1978	1980
Agriculture	0.44	1.07	1.42	1.13
Mining (excluding oil)	2.88	0.74	0.99	3.09
Oil Extraction	5.68	6.79	7.45	3.96
Food Products	5.21	8.95	10.01	17.41
Textiles and Leather	5.37	2.55	4.08	4.19
Wood Products	1.56	2.81	3.39	4.12
Paper Products	13.68	14.67	13.80	17.54
Chemical Products	16.16	17.81	19.13	23.97
Non-Metalic Minerals	6.15	4.28	7.04	4.28
Metallurgy	14.98	23.13	15.79	22.47
Equipment and Machinery	20.42	21.59	23.96	24.56
Other Manufactures	21.92	16.29	13.87	15.78

Source: Rogelio Arellano-Cadena (1990), Table VI.5 p. 181.

Note: The import substitution coefficient is defined as M(i)*100/(VA(i)+M(i), where M(i) is the imported inputs by industry i, and VA(i) is its value added. It was calculated with data from Input-Output tables published by INEGI.

According to Ten Kate (1992), Mexican policy makers acknowledged that the lack of economic growth was partly due to inefficient productive structures resulting from the adoption of the ISI strategy, to the increasingly larger participation of the government in the economy, and to some extent, the adopted policy against foreign investment. To bring the economy back to the path of growth and lower inflation, in 1983 the administration of incoming president De La Madrid adopted a series of policies aimed at reducing such inefficiency in production and government participation in the economy while encouraging foreign investment. The policies adopted by the De La Madrid administration consisted of 1) promoting trade liberalization, 2) undertaking a process of privatization of state-owned companies and 3) adopting a less restrictive foreign investment policy.

In 1983, the authorities began the process of trade liberalization by lowering import tariffs while maintaining import licensing on all imports. During the next few years both tariffs and import licensing were continuously lowered. According to Zabludovsky (1989, p. 448) by the end of June 1985, Mexican imports had an average tariff of 21.1 percent compared to a 27.0 percent in December 1982. Moreover, import licensing, as a percentage of merchandise imports, also decreased from 100.0 percent in 1983 to about 83.0

percent in 1984 (see Table 2.11). Nevertheless, Ten Kate (1992) noted that the Mexican authorities abolished only licenses for goods not produced in Mexico. He also noted that most of the imported goods competing with domestically produced goods remained under import licensing.

On July 25, 1985, the Mexican authorities decided to accelerate the structural reform that aimed at reducing dependence on oil exports and foreign borrowing while increasing efficiency of the Mexican industry through greater exposure to international competition. The structural reform, that began in 1983, was now further accelerated with the July Decree in combination with an acceleration in the rate of depreciation of the nominal exchange rate. The July Decree removed import licensing for almost 3,600 tariff lines, leaving only 908 under control. In addition, the July 1985 Decree called for increasing import tariffs and increasing the official prices in the second half of 1985.

According to Table 2.11, import licensing as a percentage of merchandise imports decreased from 83.0 percent in 1984 to 35.1 percent in 1985. Moreover, import licensing as a percentage of total domestic production fell from 92.2 percent to 47.1 percent from June to December 1985. During the same period the average import tariff increased from 23.5 percent to 28.5 percent, while official

Table 2.16. Mexico's Import Licensing, Average Tariff and Official Import Prices

	1980	1985		1986		1987		1988		1989		1990	
	April	June	Dec.	June	Dec.	June	Dec.	June	Dec.	June	Dec.	June	Dec.
Proportion of Total Production of Goods Under Import Licensing	64.0	92.2	47.1	46.9	39.8	35.8	25.4	23.2	21.3	21.8	19.8	19.6	17.9
Average Tariff Weighted With Total Production of Goods	22.8	23.5	28.5	24.0	24.5	22.7	11.8	11.0	10.2	12.6	12.5	12.5	12.4
Proportion of Total Production of Goods Under Official Import Prices	13.4	18.7	25.4	19.6	18.7	13.4	0.6	0.0	0.0	0.0	0.0	0.0	0.0

Source: Adriaan Ten Kate (1992b), Table 1 p. 521; Table 2 p. 522; and Table 3 p. 522.
Note: Official Import Reference Prices were eliminated on January 11, 1988.

prices coverage, as a percentage of domestic output, increased from 18.7 percent to 25.4 percent (see Table 2.16).

One could argue that, as a result of the July 1985 Decree, import licensing reduction was compensated, to some extent, by higher import tariffs and higher official prices in addition to a 20 percent Peso depreciation that followed the reform. In other words, these events suggest that the elimination of import licenses was redundant as no import boom took place in the following years after the July decree was put into effect. In fact, merchandise imports decreased by 5.9 percent in 1986 (see Table 2.17).

The trade reform of July 1985, adopted during a period of heavy capital flight, marked a change in the management of Mexico's macroeconomic policies. Contrary to the policies adopted in previous years consisting of the introduction of additional import restrictions to correct for balance of payments imbalances, in 1985 the authorities adopted the exchange rate as a chief policy tool to correct such imbalances. Moreover, after the initial nominal devaluation of 20 percent in July 1985, the nominal exchange rate continued to depreciate at a rate which was above Mexico's inflation. That exchange rate policy allowed for a continuous real depreciation of the Peso during 1986, 1987 and part of 1988 (see Figure 2.4). The trade liberalization

Table 2.17. Mexico's Imports of Merchandise,1957-1991
Percentage Change from Previous Year

Year	Merchandise Imports			
	Total	Consumption Goods	Intermediate Goods	Capital Goods
1958	-2.3	3.2	-5.4	-2.2
1959	-10.8	-13.8	-4.2	-14.5
1960	17.9	9.3	10.9	27.4
1961	-4.0	4.7	-6.6	-5.4
1962	0.4	3.2	-0.8	0.1
1963	8.5	23.6	10.1	0.9
1964	20.4	6.0	17.1	30.6
1965	4.5	-0.3	13.1	0.5
1966	2.7	-4.1	4.0	4.6
1967	8.4	-4.3	2.3	18.1
1968	10.4	9.6	6.1	13.5
1969	3.7	-0.2	11.3	0.2
1970	17.1	54.4	12.9	8.7
1971	-3.1	-4.3	1.9	-6.3
1972	22.5	46.7	15.3	17.4
1973	40.9	42.7	54.0	29.9
1974	58.0	51.5	77.4	44.1
1975	9.0	-50.5	50.6	-0.3
1976	-6.0	-19.2	0.8	-13.2
1977	-9.5	-10.6	-2.3	-23.2
1978	38.8	29.4	42.1	33.7
1979	51.3	53.9	40.1	80.4
1980	57.7	144.4	52.3	44.8
1981	26.7	14.7	20.3	46.4
1982	-39.7	-46.0	-37.9	-40.6
1983	-40.8	-59.5	-31.8	-51.2
1984	31.6	38.2	36.5	17.1
1985	17.4	27.5	14.5	23.0
1986	-5.9	-21.8	-3.7	-6.7
1987	7.0	-9.3	14.8	-11.0
1988	52.4	150.3	44.6	53.1
1989	25.5	82.1	19.9	18.4
1990	22.9	45.7	12.9	42.4
1991	22.1	10.6	24.2	24.8

Source: Banco de México, Indicadores Económicos.

policies adopted by the Mexican authorities continued through the end of the De La Madrid administration (1988) and have been furthered throughout the current administration of Salinas De Gortari.

In March 1986, after lowering the 100 percent tariff level to a maximum level of 50 percent, an across-the-board tariff reduction calendar was announced. According to such calendar tariffs would be reduced from 0-50 percent to 0-30 percent in four consecutive steps with the final step taking place in October 1988. Moreover, as Table 2.16 shows, a weighted average tariff decreased to 24.5 percent in December 1986 from 28.5 percent in December 1985. Also, import licensing and official import prices continued to be lowered during the same period. Another important step taken by the authorities to make Mexico's economy more open consisted of joining the GATT in August 1986. This measure, according to the authorities, increased the credibility of the government policies among both domestic investors and foreign financial institutions.

During 1986 the Peso continued to depreciate which together with a high fiscal deficit and an inflation rate above 100 percent, convinced the Mexican authorities to make a lower inflation rate the top policy objective from then on. At that point the authorities considered correcting for balance of payments imbalances a second priority.

To help reduce Mexico's inflation, the authorities decided to decrease the rate of nominal depreciation. However, by 1987, the real exchange rate began to appreciate as the authorities slowed down nominal depreciation at a rate that was smaller than Mexico's rate of inflation. Nonetheless, inflation continued its upward trend throughout the year. Moreover, as 1987 came to an end, a crisis developed in the Mexican stock market (October 1987) that was accompanied by significant capital flight. Facing these new developments, the authorities decided to reverse the exchange rate policy and accelerated the nominal rate of depreciation of the exchange rate in November of that year.

By the end of 1987, the authorities decided that trade liberalization alone was not enough to bring down inflation and adopted the Economic Solidarity Pact (PSE) in December of that year. Under the PSE, trade liberalization played an important role in lowering inflation. As a result, trade liberalization was accelerated by changing the tariff structure to a less complicated system with only five levels from 0 to 20 percent ad valorem. Next, in July 1988, the authorities adopted a Harmonized Tariff System that made the tariff classification more uniform according to GATT specifications. Since then, throughout the Salinas administration, no major changes have occurred. By 1990, Mexico's three major trade barriers stood at unprecedented

Table 2.18. State-Owned Enterprises in Mexico

Concept	1960	1970	1976	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Companies with a Majority of Participation				744	700	703	629	528	437	252	229	147	114	100
Companies with a Minority of Participation				78	78	78	69	7	3	0	0	0	0	0
Decentralized Organizations				102	97	95	96	94	94	89	88	82	82	82
Public Trusts				231	199	173	147	108	83	71	62	51	43	35
Total	360	527	635	1155	1074	1049	941	737	617	412	379	280	239	217

Source: Banco de México, Annual Reports and The Mexican Economy 1993.

low levels (see Table 2.16).

The second most important policy adopted by the De La Madrid administration during 1983 was the undertaking of a process of privatization of state-owned companies (the first major policy was the trade liberalization reform described above). During the privatization process, which has been intensified by the Salinas administration, the Mexican authorities have lowered their ownership of public enterprises from 1,155 in 1982 to 223 in 1992 (see Table 2.18). Furthermore, the share of the public sector's GDP in total GDP has diminished as well, from 25.4 percent in 1983 to 19.9 percent in 1990 (see Table 2.19). Other changes in Mexico's industrial policy of the 1980s and 1990s consisted of lowering or dissipating most of the subsidies in energy, railroad transportation, and interest rates which were also contributing to increasingly larger fiscal deficits.

The third key policy of the De La Madrid administration, as far as industrial policy is concerned, refers to the adoption of a much less restrictive foreign investment policy for non-residents of Mexico. According to Zabludovsky (1989), the previous Mexican Law of Foreign Investment of 1973 did not contain specific guidelines for regulating foreign investment. That made the authorization of foreign investment in Mexico uncertain, largely discretionary and time consuming, which discouraged foreign

Table 2.19. Mexico's Gross Domestic Product of the Public Sector in Billions of Mexican Pesos

Year	Public Sector GDP		Shares of Public Sector GDP	
	Billions of Pesos	Share of Total GDP Percent	General Government Percent	Public Enterprises Percent
1975	463.0	14.6	-	-
1980	827.3	18.5	42.7	57.3
1981	1,168.9	19.1	40.8	59.2
1982	2,232.9	22.8	38.5	61.5
1983	4,548.1	25.4	38.0	62.0
1984	7,238.2	24.6	38.5	61.5
1985	10,680.7	22.5	38.8	61.2
1986	16,398.3	20.6	40.5	59.5
1987	42,143.6	21.9	39.8	60.2
1988	74,051.8	19.0	40.5	59.5
1989	94,827.0	18.8	41.3	58.7
1990	135,109.0	19.9	41.1	58.9

Source: Banco de México, Annual Reports and The Mexican Economy 1992.

investors. New regulations for foreign investment were introduced with a Decree on May 16, 1989. Under the new regulations, out of 122 economic activities, only 8 are reserved to the State and 18 to Mexican citizens. One hundred percent foreign-owned investment was permitted in automobiles, capital goods, textiles, agroindustry and agriculture. Other changes of the new foreign investment law of 1989 include simplified administrative procedures and shorter resolution periods that in most cases will save as much as a year in the authorization process. Also, authorization to foreign investors to operate in restricted sectors will be allowed on a temporary basis up to 20 years.

The Mexican authorities expect that this new foreign investment regulation will bring new inflows of foreign investment that will contribute to job creation and to economic growth, as the transfer of technology associated with those investment flows increases productivity and international competitiveness while at the same time they facilitate access to foreign markets (Zabludovsky 1989).

By implementing a trade liberalization policy, among other policies, the Mexican government has attempted to shift from an inward-looking industrialization system to an export promotion model.

Summary and Implications for the Econometric Estimation

Following the Second World War, Mexico adopted a development strategy that consisted of increasing the government's participation in the economy while implementing trade barriers aimed at protecting Mexico's domestic producers from foreign competition. That model of economic development is referred to as the Import Substitution Industrialization (ISI).

During the period of the ISI, 1957-1971, Mexico grew at the very impressive rate of over 7 percent while enjoying inflation rates of less than 4 percent. In addition, the average real minimum wage grew at positive rates. Moreover, during the ISI strategy monetary and fiscal policies were not expansionary, which among other things, allowed the Mexican authorities to finance its public sector deficits without much debt monetizing or foreign borrowing. In spite of these achievements, by the end of the ISI strategy the participation of the government in the economy had reached significant levels, which together with highly protective trade barriers, made the Mexican industry not only unable to produce and sell in markets abroad but also very dependent on imported inputs and capital goods.

Following the ISI strategy, Mexico undertook a "public-expenditure-led growth model that lasted from 1971 to 1982, in which growth averaged a little under 7 percent a year. During the Echeverría administration, the first six years of that period of highly expansionary fiscal and monetary policies, Mexico endured higher rates of inflation which, together with a fixed nominal exchange rate, resulted in a continuous real appreciation of the Mexican currency. At the same time, large current account deficits and a capital flight developed which were accompanied by borrowing abroad and by depleting the international reserves held at Mexico's central bank. In the end, external borrowing was less easy to obtain and international reserves reached such low levels that the Central Bank was not able to support Mexico's fixed exchange rate. At that point the Mexican authorities depreciated the Mexican peso significantly.

Most of the last six years of the "public-expenditure-led" growth model, that corresponded to the López-Portillo administration (1977-1982), were also characterized by very expansionary fiscal and monetary policies. During these "oil-boom" years (1978-1981), public spending, that was supported by oil export revenues and heavy external borrowing, was much higher than in the previous administration. As fiscal deficits reached historical proportions, so did capital flight. In addition, as inflation surged to almost 100 percent, and international reserves at the central bank fell significantly, external financing, once again, became difficult to obtain. To deal with this situation, the Mexican authorities undertook some drastic measures. First, during mid-August 1982, the Mexican government confiscated all dollar-denominated deposits in Mexico's commercial banks and made them payable only in Mexican Pesos at an exchange rate much lower than the free market rate. Next, in late August of the same year, Mexico requested a moratorium on payments of principal on its public external debt. Finally, President López-Portillo, in his last presidential address, announced that all private commercial banks would be nationalized and that foreign exchange controls would be implemented, effective September 1, 1982.

By 1982, a year that marked the end of the "public-expenditure-led" growth model and the end of the "oil-boom" years, the new administration of Miguel De La Madrid faced an economy with heavy government spending, a large number of loss-making companies owned by the public sector (producing about 25 percent of Mexico's GDP), an exporting sector heavily dependent on oil, and an external debt that amounted to about 60 percent of total GDP. In addition, economic growth turned negative in that year. This situation worsened as, once again, foreign banks became unwilling to provide Mexico with new lending. At that point, Mexico (that traditionally had been a net importer of capital) became a net exporter of financial resources as servicing its external debt required historical transfers of resources abroad.

During the period of "Fiscal Correction and Stabilization", that began with former president De La Madrid in 1983 and continues to the present with the Salinas de Gortari administration, the Mexican government has undertaken various programs of stabilization and structural adjustment. The adoption of these programs has restored economic growth and price stability, while at the same time has made Mexico's economy more open and competitive. In addition, net payments abroad have significantly diminished, particularly since 1989, when Mexico completed a period of intense negotiations with the foreign financial community.

This chapter overview of Mexico allows us to identify key dates that will be taken as a reference when testing for structural change in the co-integration tests. Let us point out some of these dates in chronological order.

First, on September 1, 1976, the nominal exchange rate was devaluated for the first time since April 1954. Thereafter it was no longer fixed except from February 28, 1988 through the end of 1988.

Second, during August 1982, the Mexican authorities confiscated all dollar-denominated deposits in the Mexican banking system and made them payable only in domestic currency. Also, on August 20, Mexico requested a three-month moratorium on payments of its external debt. In addition, on September 1, all private and commercial banks were nationalized and foreign exchange controls were implemented.

Third, in November 1987, the Mexican authorities implemented a stabilization program known as the Economic Solidarity Pact (PSE) which has been renewed more than four times with its last renewal in October 1993 to expire in December 1994. In addition, prior to the adoption of the PSE, the Mexican stock market experienced a significant fall that was accompanied by capital flight (October 1993).

Finally, in November 1988, the Mexican authorities adopted open market operations as their chief policy instrument for monetary policy management and source of financing to the public sector. This measure allowed interest rates to be determined by market conditions. Next, let us describe some recent events that will update this overview.

In 1988, President Salinas de Gortari launched the Pact for Stability and Economic Growth (PECE) which had four components. The first was "orthodox", involving the implementation of restrictive fiscal and monetary policies through the management of aggregate demand (restricting government spending and increasing tax revenues) while at the same time restricting credit supply. The second was "heterodox" including incomes policies and "nominal anchors" that attempted to break the component of inflation known as "inertia." The third involved external debt renegotiation. The final component consisted of the implementation of a structural reform program with the purpose of lowering trade barriers, privatizing public enterprises and deregulating the Mexican economy (Aspe (1991), and The Mexican Economy (1993)). All four of these targets of the PECE have been pursued throughout the Salinas administration.

Structural reforms of the Mexican economy have included the privatization of numerous public firms including TELMEX (the Mexican telephone company) and commercial banks (it was completed in 1992). The resources from the sale of public enterprises (about 16 billion dollars by 1992) have been set aside in a special "Contingency Fund" at the Central Bank. For the most part, that fund has been used to reduce domestic debt instead of financing current government spending.

Financial reforms, in addition to the privatization of commercial banks, included the adoption (in late 1988) of a full reliance on open market operations to finance government spending. This implied the abandonment of the traditional required reserve ratio system as a tool of monetary policy. Also, a system of selective credit allocation was eliminated in 1989. In addition, the ceilings on interest rates paid on deposits were eliminated in April 1989, letting market conditions determine their movements. Moreover, on June 22, 1992, Mexico's Congress approved a decree establishing a new monetary unit which will preserve the name "peso" and is equivalent to one thousand old pesos. Effective January 1, 1993, the new notes and coins have been put into circulation.

Furthermore, the amendment to Article 27 of the Constitution in 1992 has brought about a change in the land tenure system. The new tenure system allows land owners (ejidatarios) to lease or transfer property rights. It also allows private businesses to participate in agricultural activities.

After undertaking a number of measures to lower barriers to trade, Mexico has focused its trade policy towards achieving closer formalized economic ties with other countries. In February 1991, Mexico, Canada and the U.S. agreed to negotiate a free trade agreement. Formal negotiations of the North American Free Trade Agreement (NAFTA) began in June 1991 and concluded on August 12, 1992. Some of NAFTA's goals are: to eliminate barriers to trade, to increase investment opportunities, to promote conditions of fair competition and to establish procedures for effective dispute resolutions. NAFTA has been ratified by the governments of the three countries and took effect January 1, 1994.

Finally, on May 17, 1993, President Salinas de Gortari sent to Mexico's Congress a proposed Constitutional Amendment that would allow the central bank to enjoy independence in the management of monetary policy. Under this proposal no government agency would be able to dictate the Bank of Mexico to issue credit or to undertake policies that differ from what the bank judges appropriate. Also, according to the Amendment, the main responsibility of the central bank will be to preserve the purchasing power of the national currency. That Amendment has been approved and will take effect in April 1994.

In summary, the economic stabilization strategy, together with the structural reforms adopted by the Mexican authorities in recent years, is expected to help bring Mexico back on the path of price stability and sustained economic growth with a more open and competitive economy in the years to come.

CHAPTER 3. A CO-INTEGRATION APPROACH TO MEXICO'S BALANCE OF PAYMENTS AND EXCHANGE RATES, 1971-1988

Introduction

The direction of causality running from domestic credit to international reserves is an important result of the monetary approach to the balance of payments (MBOP). The MBOP is important because its theoretical results are used by policy makers (Gil Díaz (1991)). In addition, the International Monetary Fund uses the MBOP when making policy recommendations to its member countries (Rhomberg and Heller (1977), Crockett (1981), and Dernburg (1989)). Not surprisingly, the MBOP has been widely tested for both the industrialized and less developed countries.[6]

The prediction of the MBOP that an exogenous increase in domestic credit will cause losses in international reserves, exchange rate depreciation, or both, is very important. For instance, if the direction of causality is not from domestic credit to international reserves and if domestic credit is not exogenous, then the MBOP's

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[6]The classical references of the monetary approach are the articles by Harry G. Johnson (1972) and by Robert A. Mundell (1968). Other references are Jacob A. Frenkel and Harry G. Johnson, editors (1976); Jacob A. Frenkel and Harry G. Johnson, editors (1978); and Bluford H. Putnam and D. Sykes Wilford, editors (1986).

theoretical results, its policy implications, and its empirical tests are questionable. Such a situation may arise when central banks adjust their domestic assets to neutralize the impacts of balance-of-payments surpluses or deficits upon the monetary base in an effort to keep the domestic money supply unchanged. In this instance, domestic credit is no longer exogenous and the direction of causality runs in the opposite direction, from foreign reserves to domestic credit. Consequently, it is essential to test the causal relationship between domestic credit and international reserves.

Several statistical tests have been conducted to determine the direction of causality between these variables, as shown in the studies by Blejer (1979), Feige and Johannes (1981), Johannes (1981), Gupta (1984), and Taylor (1987).

The definition of causality used in those studies and in this paper is the one proposed by Granger (1969).[7] Blejer (1979), applied bivariate Sims (1972) tests to five European countries and found that the direction of causality was from domestic credit to international reserves. Feige

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[7]As Arnold Zellner (1979) pointed out, this definition of causality proposed by C.W.J. Granger (1969) is controversial, although it is widely adopted in econometric work. Its usefulness is based upon the fact that causality is characterized by reducing the OLS forecasting variance of a regression, given an information set.

and Johannes (1981), employing Granger (1969), Haug (1976), and Sims (1972) bivariate tests on six European countries, showed a bidirectional causality between these two variables. Johannes (1981), using Granger (1969) tests, also found a bidirectional causality. Gupta (1984) applied the same methodology used by Feige and Johannes (1981) to five developing countries, including India, Malaysia, Mexico, and Taiwan. Gupta's bivariate tests also found a bidirectional causality between domestic credit and international reserves. Finally, Taylor (1987), using data on the U.K., also found Granger causality running from international reserves to domestic credit.

Nonetheless, there are two potential problems with the methodology used by those authors. First, the statistical procedure for those studies involves testing for nonstationarity. When present, nonstationarity is removed by either filtering or by differencing the time series under study. The problem is that if the time series involved show a long-run relationship, or if their nonstationarity arises from the same common source, (in other words, they share a common stochastic trend), then they should be modeled as co-integrated variables. This is because differencing purges the data from its long-run relationship. In other words, as Granger (1986) and Engle and Granger (1987) have shown, modeling co-integrated data in differences will result in misspecification error, while modeling the same data in levels will overlook important constraints. Engle and Granger suggest modeling co-integrated variables as an error-correction model, which includes a long-run error-correction term while allowing for short-run dynamics captured by the differenced variables.

The second problem with those causality tests is that they were conducted in a bivariate framework. Thus, the authors assume that no other variables affect the two variables involved. In fact, this type of causality test, which excludes relevant variables such as prices, expected rates of inflation, interest rates, or output, might, as Skoog (1976) points out, induce specification error and therefore should be conducted in a multivariate framework.

Beginning in the 1970s, in contrast to earlier years, Mexico's monetary and fiscal policies turned very expansionary. After enjoying a period of sustained economic growth and price stability, Mexico experienced an inflation rate of 159.2 percent in 1987, an increase in the money supply (currency plus demand deposits) of 130 percent in 1987, a budget deficit as a proportion of GDP of about 17 percent in 1982, a loss in international reserves of about 7 billion dollars in 1982, and a nominal devaluation of the

Mexican peso by several hundred percent (see Chapter 2).[8] These wide fluctuations in Mexico's macro-variables suggest that the data could be nonstationary, and it would therefore be suitable to formally test it for co-integration.

In this chapter, co-integration techniques are used to test whether a negative bidirectional Granger causality between growth in international reserves and the exchange rate and growth in domestic credit is consistent with Mexico's time-series data. The tests are performed as multivariate Granger causality tests, which include measures of inflation, the money multiplier, output, and foreign inflation.[9] The results obtained show that, for the period 1971 to 1988, Mexico's data appear to be nonstationary. In addition, a long-run relationship as suggested by the monetary approach to the balance of payments and exchange rate is clear. Furthermore, Mexico's data support the causality direction proposed by both the monetary approach and the sterilization policies undertaken by Mexico's monetary authorities. In other words, Mexico's growth rates

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[8]Studies of Mexico's economy during this period of time include Francisco Gíl Díaz (1984), Alain Ize and Gabriel Vera (1984), Guillermo Ortíz (1985), Francisco Gíl Díaz and Raúl Ramos Tercero (1988), Van Wijnbergen (1988), Víctor M. Guerrero and Luis G. Arias (1990), Jose Angel Gurria (1990), and Guillermo Ortíz (1990).

[9]A similar application of this methodology includes Yash P. Mehra's (1991) work on wage growth and inflation process in the U.S.

in domestic credit, international reserves, and the exchange rate are co-integrated and consistent with Granger causality from domestic credit to international reserves and the exchange rate, as well as from international reserves and the exchange rate to domestic credit.

This chapter is organized as follows. The following section presents a relationship between domestic credit and international reserves based on a monetary model of the balance of payments and the exchange rate. The next section describes Granger causality tests and co-integration theory. The last two sections present the empirical results of the statistical tests and some conclusions.

A Monetary Model of Balance of Payments and the Exchange Rate

A long-run monetary model that explains changes in international reserves and exchange rates was developed by Girton and Roper (1977). This model, known as the Girton-Roper monetary model of exchange market pressure (EMP), has been expanded by Connolly and Da Silveira (1979), Modeste (1981), Connolly and Lacky (1984), and Kim (1985).

A version of the EMP model can be derived by assuming a stable money demand, a money supply identity, a purchasing-power-parity relationship, and a monetary equilibrium condition. For a small open economy that faces given prices for goods and capital determined in world markets, and in which the money supply and money demand adjust instantaneously, the following money market can be modeled:[10]

$$M^d = P \cdot f(Y, \pi) \tag{3.1}$$

$$M^s = A(R + C) \tag{3.2}$$

$$P = EP^* \tag{3.3}$$

$$M^d = M^s \tag{3.4}$$

where M^d is the nominal demand for money, P is the domestic price level; Y is the real income; π is the expected rate of inflation or opportunity cost of holding money[11]; M^s is the money supply; A is the money multiplier; R is net foreign-exchange reserves in terms of domestic currency held by the central bank; C is domestic credit; E is the exchange rate, defined as the price of one unit of foreign currency in

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[10]Instantaneous adjustment in the money market means that the residents of a country can get rid of money either through the international market for commodities or through the international market for securities.

[11]Most studies of money demand include some measure of interest rates. However, during inflationary periods the interest rate no longer represents the opportunity of holding money. Thus, a measurement of the expected rate of inflation is used instead. See Guillermo Ortíz (1980) and Rafi Melnick (1990).

terms of domestic currency; and P^* is the foreign price level. The demand for money, equation (3.1), is assumed to be homogeneous of degree one in prices and a function of real output and the expected rate of inflation, with positive and negative partial derivatives, respectively. The money supply, equation (3.2), states that changes in the money stock derive from a change in foreign reserves via the balance of payments, a change in domestic credit created by the central bank, or a change in the money multiplier. The sum of R plus C is the monetary base or high-powered money. The purchasing-power-parity relationship is shown by equation (3.3). It illustrates how the demand for money is affected, through changes in the domestic price level, as the exchange rate or the foreign price level change. The money market equilibrium condition, equation (3.4), establishes that money demand and money supply adjust rapidly. In the presence of an excess supply of money, equilibrium is restored either by a decrease in international reserves (decreasing the stock of money) or by exchange rate depreciation (an increase in nominal money demand), or some combination of the two. Under a system of fixed exchange rates, the stock of money adjusts through changes in international reserves, while under flexible exchange rates the money demand adjusts through changes in the exchange rate. In a mixed system, both international reserves and exchange rates change such that money market equilibrium is restored.

Now, substituting equation (3.3) into (3.1), and equations (3.1) and (3.2) into (3.4), taking natural logarithms of both sides, and differentiating with respect to time, after some manipulation, the long-run Girton-Roper model of exchange market pressure (EMP) is obtained:

$$(r - e)_t = -c_t - a_t + y_t - \pi_t + p_t^* \tag{3.5}$$

where r_t is the change in foreign reserves, or balance of payments, as a proportion of the monetary base; e_t is the percentage change in the exchange rate; c_t is the change in domestic credit as a proportion of the monetary base; a_t is the rate of change of the money multiplier; y_t is the percentage change of real income; π_t is the expected rate of inflation; p_t^* is the percentage change in the foreign price level; and the subscript t denotes time.

From equation (3.5), the following conclusions, ceteris paribus, can be derived: (i) if the exchange rate is fixed, $e_t = 0$, an increase in c_t will cause losses in international reserves; (ii) if the exchange rate is fully flexible, $r_t = 0$, an increase in c_t will cause exchange rate depreciation; and (iii) under a managed float regime, an increase in c_t will cause either foreign exchange losses, or exchange rate depreciation, or both. Therefore, expansion of domestic credit in excess of domestic demand for money will result in either a balance-of-payments deficit, or exchange rate depreciation, or both, as the public gets rid of the excess supply of money. These conclusions suggest that, according to the Girton-Roper monetary model of exchange market pressure, equation (3.5), the direction of causality is from c_t to $(r-e)_t$, which assumes, among other things, that domestic credit is exogenous.

Empirically, the monetary approach to the balance of payments and exchange rates has been widely tested on data from Mexico. Again, assuming that domestic credit is exogenous, those studies support a negative causality from c_t to $(r-e)_t$. (see Wilford (1977), Blejer (1977), Wilford and Zecher (1979), Rasulo and Wilford (1980), Wilford (1984), Connolly and Lackey (1984), Kamas (1986), and Connolly and Fernandez-Perez (1987)). Studies questioning that domestic credit is exogenous in those studies of Mexico, center on the sterilization issue.[12] Cumby and

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[12]The theoretical literature has dealt with this issue in the works by Robert A. Mundell (1963), and Russel S. Boyer (1979). The empirical literature has followed three approaches: (a) estimation of reduced form equations as in Victor Argy and Pentti J.K. Kouri (1974), Pentti J.K. Kouri and Michael G. Porter (1974), Donna Bean (1976), Hans A. Genberg (1976), Norman C. Miller and Sherry S. Askin (1976), and Lance Girton and Don Roper (1977); (b) estimation of structural equations as in Robert E. Cumby and Maurice Obstfeld (1983); and (c) estimation of Granger causality tests

Obstfeld (1983), for instance, estimated a structural model for Mexico and found that the central bank of Mexico indeed sterilized movements in international reserves, particularly during the late 1970s. Gupta (1984), using Granger tests, also found statistical evidence of a bidirectional causality between domestic credit and international reserves. Those studies were conducted using data from no later than 1980 and did not account for the possibility of co-integration. This issue of co-integration is a topic of the next section.

Granger Causality Tests and Co-integration

In this section, Granger causality, stationarity, and co-integration are discussed.

Simply stated, a variable X_{1t} Granger causes X_{2t} if past values of X_{1t} improve the forecast of X_{2t}. Let X_1, X_2, and X_3 be stationary stochastic processes with their set of past values $\overline{X}_1$, $\overline{X}_2$, and $\overline{X}_3$, respectively. Let $\sigma^2\ (X_t\ |\Omega)$ be the conditional mean square error or conditional variance of the error series of the optimum unbiased, least squares predictor of X_2, given the relevant information set Ω.

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as in Mario I. Blejer (1979), Edgar L. Feige and James M. Johannes (1981), James M. Johannes (1981), Senjeer Gupta (1984), and Mark P. Taylor (1987). The present paper falls within the Granger causality approach and extends it by using co-integration theory.

Here, the relevant information set Ω may contain $\bar{X}_1$, $\bar{X}_2$, and $\bar{X}_3$. Thus, in a two-variable case, X_{2t} is Granger caused by $\bar{X}_{1t}$ if

$$\sigma^2 \, (X_{2t} \mid \bar{X}_1, \bar{X}_2) < \sigma^2 (X_2 \mid \bar{X}_2) \tag{3.6}$$

In a three-variable case, Granger causality is defined similarly. Here, X_{2t} is Granger caused by X_{1t} conditional on X_{3t} if

$$\sigma^2 \, (X_{2t} \mid \bar{X}_1, \bar{X}_2, \bar{X}_3) < \sigma^2 (X_2 \mid \bar{X}_2, \bar{X}_2) \tag{3.7}$$

In a multivariate case, the definition of Granger causality is analogously defined.

To test for Granger causality, one can examine whether lagged values of one series add statistically significant predictive power to another series' own lagged values for one-step ahead forecasts. If so, the first series is said to "Granger cause" the second. In this chapter, we are interested in testing for causality between c_t and $(r-e)_t$, while at the same time accounting for other variables (e.g. a_t, y_t, π_t and P_t^* , see the EMP equation (3.5) above). In a simple case that consists of c_t, $(r-e)_t$, and a_t, the Granger procedure consists of estimating two regressions:

$$c_t = \delta_1 + \sum_{i=1}^{n} \beta_{1i}\; c_{t-i} + \sum_{i=1}^{n} \beta_{2i}\; (r-e)_{t-i} + \sum_{i=1}^{n} \beta_{3i} a_{t-i} + \epsilon_{1t} \qquad (3.8)$$

$$(r-e)_t = \delta_2 + \sum_{i=1}^{n} \theta_{1i}\; c_{t-i} + \sum_{i=1}^{n} \theta_{2i}\; (r-e)_{t-i} + \sum_{i=1}^{n} \theta_{3i} a_{t-i} + \epsilon_{2t} \qquad (3.9)$$

where c_t, $(r-e)_t$, and a_t are defined as before; δ_1, δ_2, the β_is, and the θ_is are regression coefficients; ϵ_{1t} and ϵ_{2t} are white-noise error terms; and n is the lag length. If an F-test shows the estimated β_{2i}s in (3.8) to be statistically significant, then the series $(r-e)_t$ Granger causes c_t conditional on a_t. Likewise, if the estimated θ_1s in (3.9) are statistically significant, then the series c_t Granger - causes $(r-e)_t$ conditional on a_t. Granger (1969) has shown that the operational definitions of causality (3.8) and (3.9) are equivalent to the formal definition (3.7). To account for additional variables (y_t, π_t and p_t^*) in the test for causality we apply an analogous methodology.

Recently, Sims, Stock, and Watson (1986), Phillips (1986), and Ohania (1988) have shown that if the series included in the causality test are nonstationary -- i.e., they contain unit roots -- then the F-statistics will have nonstandard distributions, and thus any conclusions based on these F-tests will be misleading. In addition, the ordinary least squares estimators of a regression with variables containing unit roots are not consistent (West (1988)). In this chapter, stationarity is a key issue because Mexico's data seem to display nonstationarity, as will be shown later on. The implication of nonstationarity is crucial, since a variable that exhibits nonstationarity shows no tendency to return to its long-run or average value after a disturbance has taken place. In other words, conventional econometric techniques require stationarity.[13]

Furthermore, stationarity in a variable is an important property for several reasons. First, stationarity guarantees that the effects of a random disturbance on a variable will die out over time. Second, if nonstationary variables are used in statistical tests, any conclusions based upon t- or F-ratio tests will be misleading and can lead to spurious relationships. Third, the regression

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[13]Following Judge, et al. (1988, p. 679), a stochastic process X_t is stationary if it has a constant mean and a finite variance. More formally, a stochastic process X_t is stationary, if

i. $E(X_t) = \mu$ for all t

ii. $var(U_t) < \infty$ for all t

iii. $cov(U_t, X_{t+k}) = E[(X_t - \mu)(X_{t+k} - \mu)] = \gamma_k$

for all t and k, where E(.) is the expected value operator and μ and γ_k are constants.

estimators of a regression with unit root variables will not be consistent.[14] Fourth, and perhaps the most relevant for this chapter, in the estimation of long-run or equilibrium relationships, it is important to determine whether a variable is stationary or not. To elaborate on this, let us use the Girton-Roper exchange market pressure model.

According to equation (3.5), the behavior of the rates of growth in domestic credit c_t and international reserves and the exchange rate $(r-e)_t$ must be related in the long run. Moreover, if long-run components in c_t and $(r-e)_t$ are modeled as stochastic trends and if they move together -- i.e., they share a common trend -- then these two times-series should be co-integrated, as discussed in Granger (1986) and Engle and Granger (1986). Stated differently, if two variables are co-integrated, a long-run relationship exists between them because the source of nonstationarity is common to these variables. This argument can be summarized as follows: suppose that c_t and $(r-e)_t$ each contain a unit root, but Δc_t and $\Delta(r-e)_t$ do not. To determine causality directions between c_t and $(r-e)_t$, we could use first differences, since by assumption they do not contain unit roots and the statistical properties of the F-tests make their use appropriate (in general, these variables may or

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[14]For consistency's implication for OLS, see Judge, et al. [1988].

may not contain unit roots). However, using variables in first difference would be inappropriate if c_t and $(r-e)_t$ are co-integrated as their long-run relationship would be ignored. This is because first differencing purges the data of long-run movements and therefore valuable information is lost. According to Granger (1986) and Engle and Granger (1987), the appropriate way to deal with this problem is to estimate an error-correction model which is discussed in the last part of this section.

Engle and Granger (1987, pp. 252-53) illustrate co-integration theory by way of the following definitions:

" A series with no deterministic components which has a stationary, invertible ARMA representation after differencing d times, is said to be integrated of order d, denoted by $x_t \sim I(d)$."

" The components of the vector x_t are said to be co-integrated of order d, b, denoted $x_t \sim CI(d,b)$, if (i) all components of x_t are I(d); (ii) there exists a vector $\alpha(\neq 0)$ so that $z_t = \alpha' x_t \sim I(d-b)$, $b>0$. The vector α is called the co-integrating vector."

To illustrate, let us assume a vector x_t which contains two variables, such that $x_t \sim CI(1,1)$. If these two variables are co-integrated, it means that both variables of x_t achieve stationarity after taking their first difference, and at least one linear combination of its elements is stationary without taking any differences at all. Co-integration of order (1,1) implies that the two series will not drift away from each other; instead, the difference between them will be stationary. At present, several co-integration tests have been developed -- by Engle and Granger (1987), Johansen (1988), Stock and Watson (1988), and Fountis and Dickey (1989). The methodology adopted here is that of Engle and Granger (1987).

Engle and Granger's test for co-integration consists of two steps. The first is to test whether each variable has one or more unit roots or, in other words, to determine the degree of integratability (e.g. the value of d). This is done by performing the augmented Dickey-Fuller test for unit roots on a given time series X_t, which requires estimating the following regression:

$$\Delta X_t = \mu_0 + \mu_1 T + \rho X_{t-1} + \sum_{i=1}^{n} \gamma_i \Delta X_{t-i} + \epsilon_{xt} \qquad (3.10)$$

where Δ is the first difference operator, i.e., $\Delta X_t = X_t - X_{t-1}$; X_t is the time series under study; μ_0, μ_1, ρ, and the γ_is are regression coefficients; T is a time trend; and ϵ_{xt} is a white-noise error term (Dickey and Fuller (1979)).[15]

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[15]Another test for unit roots is the Phillips-Perron test which is discussed in Chapter 4. Both tests, the augmented Dickey-Fuller test and the Phillips-Perron test are asymptotically equivalent.

Next we test the null hypothesis H_0: $\rho = 0$ against the alternative hypothesis H_1: $\rho > 0$. The null hypothesis states that the series X_t contains a unit root, or X_t is non-stationary. The test statistic to test the null hypothesis is the standard t-statistic, which is the ratio of the estimated coefficient to its standard error. However, under the null hypothesis, this test statistic does not have the usual t-distribution, and thus, the critical values given in Fuller (1976, p. 373) are used. Taking absolute values, we reject the null hypothesis if the t-statistic is greater than the critical values given by Fuller (1976), at some desired significance level. If it is determined that all variables are integrated of the same order d -- i.e., they have the same number of unit roots -- then step 2 is followed.

Step 2 is to determine whether the stochastic trends in these variables are related to one another. This is equivalent to determining whether there is a long-run relationship between variables that contain unit roots. In general, we do this by estimating an equilibrium or co-integrating equation (in the present case equation (3.5)), and then test whether the residuals of that regression, say, V_t, are stationary or not.

Now, if V_t appears to be stationary -- i.e., it does not contain a unit root, while c_t, $(r-e)_t$, a_t, y_t, π_t, and p_t^*

each have a unit root -- then these variables are said to be co-integrated. In that case, ordinary least squares estimators of (3.5) are consistent as shown by West (1988). The null hypothesis, H_0: no co-integration, or, equivalently, V_t is non-stationary, is tested by checking for the statistical significance of the estimated ϕ in the following regressions:

$$\Delta V_t = -\phi V_{t-1} + \epsilon_{vt} \tag{3.11}$$

$$\Delta V_t = -\phi V_{t-1} + \sum_{i=1}^{4} g_i \Delta V_{t-i} + \epsilon_{vt} \tag{3.12}$$

where Δ is the first difference operator, V_t is the residual from the co-integrating regression equation (3.5), and ϵ_{vt} is a white-noise disturbance. The standard t-statistic is used to test for the significance of ϕ. The null hypothesis is rejected in favor of co-integration if the estimate of ϕ is statistically different from zero. For the bivariate case, the critical values for the Dickey-Fuller test (DF) regression (3.11) and the augmented Dickey-Fuller test (ADF) of regression (3.12) do not have the usual t-distribution, but are given in Engle and Granger (1987). For the multivariate case, the critical values for both of these tests are given in Engle and Yoo (1987).

The existence of a co-integration equation tells us only about long-run relationships, but the short-run dynamics are also important. Let us consider next the issue of co-integration and error-correction models. A problem with nonstationarity is that it restricts variables to entering a model in differenced form. Furthermore, if a long-run relationship exists among these variables and they are differenced, then that relationship will be ignored. A solution to this problem is to model the co-integrated variables as an error-correction model.[16] An error-correction model allows for short-run movements while imposing gradual adjustment of the dependent variable toward a long-run or equilibrium value. That is, it relates the change of the dependent variable to lagged changes of the dependent variable itself, lagged changes of the independent variables, and a lagged equilibrium error. Here the lagged changes of the dependent and independent variables capture the short-run movements, while the lagged error captures the adjustment toward the long-run equilibrium. Furthermore, as Engle and Granger (1987) have shown, if two variables are

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[16]Error-correction models were introduced by J.E.H. Davidson, D.F. Hendry, F. Srba, and S. Yeo (1978) in an article on aggregate consumption behavior. In general, any equation that expresses the change in a variable as a function of the difference between that variable and its target or long-run value can be interpreted as an error-correction model. This is because the error between the endogenous variable and its target causes a correction in the endogenous variable. Other studies applying error-correction models include D.F. Hendry (1980), T.J. Jenkinson (1986), Brian M. Lucey (1988), and B. Motley (1988).

co-integrated -- for instance c_t and $(r-e)_t$ -- then these series satisfy an error-correction model of the form:

$$\begin{aligned}\Delta c_t = \Phi_0 &+ \sum_{i=1}^{n} \Phi_{1i}\Delta c_{t-i} + \sum_{i=1}^{n} \Phi_{2i}\Delta(r-e)_{t-i} \\ &+ \sum_{i=1}^{n} \Phi_{3i}\Delta a_{t-i} + \sum_{i=1}^{n} \Phi_{4i}\Delta y_{t-i} \\ &+ \sum_{i=1}^{n} \Phi_{5i}\Delta\pi_{t-i} + \sum_{i=1}^{n} \Phi_{6i}\Delta p^{*}_{t-i} \\ &+ \lambda_1 V_{t-1} + \omega_{1t} \end{aligned} \tag{3.13}$$

$$\begin{aligned}\Delta(r-e)_t = \Psi_0 &+ \sum_{i=1}^{n} \Psi_{1i}\Delta c_{t-i} + \sum_{i=1}^{n} \Psi_{2i}\Delta(r-e)_{t-i} \\ &+ \sum_{i=1}^{n} \Psi_{3i}\Delta a_{t-i} + \sum_{i=1}^{n} \Psi_{4i}\Delta y_{t-i} \\ &+ \sum_{i=1}^{n} \Psi_{5i}\Delta\pi_{t-i} + \sum_{i=1}^{n} \Psi_{6i}\Delta p^{*}_{t-i} \\ &+ \lambda_2 V_{t-1} + \omega_{2t} \end{aligned} \tag{3.14}$$

where c_t, $(r-e)_t$, a_t, y_t, π_t, and p^{*}_t are defined as before; V_{t-1} is the residual from the co-integrating regression (3.5); ω_{1t} and ω_{2t} are white-noise error terms; and one of λ_1 or $\lambda_2 \neq 0$. The coefficients of the error-correction terms, λ_1 and λ_2, are expected to be negative and capture the adjustment of Δc_t and $\Delta(r-e)_t$ toward long-run equilibrium, while the lagged variables in the right-hand side of these equations capture the short-run dynamics of this model. Notice that λ_1 or $\lambda_2 \neq 0$ implies Granger causality in at least one direction. Granger (1988) has shown that since V_{t-1} depends on lagged c and (r-e), the model above implies that either Δc or $\Delta(r-e)$ or both must be caused by lagged c and (r-e). Intuitively, if there is a long-run relationship between c and (r-e), then there must be causation between them to provide the necessary dynamics.

This error-correction model is used to test for Granger causality by testing the statistical significance of the Φ_is and Ψ_is using the standard F-tests.

Empirical Results

As suggested in the previous section, we follow three steps. First, the unit root tests are performed by estimating the augmented Dickey-Fuller equation (3.10) for $(r-e)_t$, c_t, a_t, y_t, π_t, and p_t^*. The results of unit root tests on growth rates are presented in Table 3.1, and the results on their first differences are in Table 3.2. Second, the co-integrating regression equation (3.5) is estimated and tested for co-integration by estimating the Dickey-Fuller (DF) equation (3.11) and the augmented Dickey-Fuller (ADF) equation (3.12). Those results support co-integration and are presented in Tables 3.3 and 3.4, respectively. And third, the error-correction model, equations (3.13) and (3.14), is estimated, and the results of the Granger causality tests are reported in Tables 3.5 and 3.6.

The data are quarter averages of all series from the first quarter of 1971 to the second quarter of 1988, taken from the IMF's International Financial Statistics. This period was chosen because Mexico's monetary authorities followed policies that were very similar throughout these 18 years. Although any empirical research is subject to the Lucas critique, it is expected that the similarity in policy management during 1971-1988 will minimize the implications of the Lucas proposition.[17] The variable c_t is the change in domestic credit divided by the monetary base. It was obtained by subtracting the change in international reserves (line 79dad multiplied by line RF) from the percentage change in the monetary base. The variable r_t is the ratio of the change in international reserves in Mexican pesos (line 79dad times line rf) divided by the monetary base[18];

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[17]The Lucas critique states that if the monetary or the fiscal rule changes, then the time parameters of a model will change as well, and therefore the conclusions based on that model are no longer valid (Robert E. Lucas Jr. (1976)).

[18]Line 79dad was chosen and not line 11 because, as an anonymous referee pointed out, line 79dad, reserve assets, covers changes in holding assets resulting from market transactions that exclude valuation changes due to monetarization or demonetarization of gold, allocation or cancellation of special drawing rights, and reclassification.

e_t is the rate of change in the exchange rate, the peso price of a U.S. dollar (line rf); a_t is the rate of change in the money multiplier, obtained as a percentage change of the ratio of the money supply to the monetary base. The money supply is the sum of currency plus demand deposits. Both the money supply and the monetary base are quarterly averages of monthly observations taken from International Financial Statistics, IMF. Further, y_t, the growth rate in real income, is proxied by the rate of change in the industrial production index because quarterly income data is not available; π_t, the expected rate of inflation, is again proxied by the actual rate of inflation obtained as a percentage change in the consumer price index (line 64); and p_t^* is the foreign rate of inflation, calculated as the percentage change in the U.S. consumer price index (line 64). PC RATS by Doan (1988) was used in the estimation.

The results of the unit root tests reported in Tables 3.1 and 3.2. provide statistical evidence that c_t, $(r-e)_t$, a_t, y_t, π_t, and p_t^* all have a unit root but their first differences do not. Further unit root tests which account for structural breaks also support this conclusion (Perron's unit root tests under structural breaks are reported in Appendix A). This suggests that Granger causality tests should be performed using first differences of these

Table 3.1. Augmented Dickey-Fuller Unit Root Tests

X_t [a]	ρ [b] No Trend [c]	ρ [b] Trend [d]	LM(i) [e] No Trend (1)	No Trend (2)	No Trend (3)	No Trend (4)	Trend (1)	Trend (2)	Trend (3)	Trend (4)
c_t	-1.21 (-2.42)	-1.55 (-3.09)	0.7	1.2	1.3	1.7	1.6	2.9	3.5	3.3
$(r-e)_t$	-0.42 (-1.73)	-1.10 (-3.01)	0.0	0.6	1.0	1.6	1.3	1.4	1.4	1.5
a_t	-0.53 (-1.65)	-0.87 (-2.16)	0.2	1.1	1.0	3.9	0.5	2.0	2.2	4.1
y_t	-0.81 (-2.42)	-1.27 (-3.00)	0.2	0.7	5.4	9.3	0.0	0.1	5.9	8.8
π_t	-0.05 (-0.43)	-0.49 (-2.18)	1.8	2.5	4.1	8.3	4.0	4.9	6.3	7.9
p_t^*	-0.24 (-2.48)	-0.36 (-3.36)	0.9	1.4	2.0	3.0	0.8	1.2	1.7	2.5

Lagrange Multipliers LM(i) [e]

[a] Except for c_t and r_t all variables are percentage changes of quarterly data from 1971 to 1988. c_t = change in domestic credit/monetary base, r_t = change in international reserves/monetary base, e_t = peso price of a U.S. dollar, a_t = money multiplier, y_t = industrial production index, π_t = Mexico's inflation, and p_t^* = U.S. rate of inflation.

[b] ρ is the OLS estimate of ρ and its t-statistic is in parentheses.

[c] For T = 0, the critical values at 10%, 5%, and 1% are -2.58, -2.89, and -3.51, Fuller (1976), p. 373.

[d] For T = 1, 2,...,72, the critical values at 10%, 5%, and 1% are -3.15, -3.45, and -4.04, Fuller (1976), p. 373.

[e] For i = 1, 2, 3, 4, LM(i) are the Lagrange Multiplier test statistics proposed by Godfrey (1978) to test for ith order serial correlation, and are distributed as chi-square, χ^2, with 1, 2, 3 and 4 degrees of freedom. The 5% critical values for $\chi^2(1) = 3.84$, $\chi^2(2) = 5.99$, $\chi^2(3) = 7.81$ and $\chi^2(4) = 9.49$.

Table 3.2. Augmented Dickey-Fuller Unit Root Tests

X_t[a]	ρ[b]		Lagrange Multipliers LM(i)[e]							
			No Trend				Trend			
	No Trend[c]	Trend[d]	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Δc_t	-3.54 (-4.93)	-3.70 (-5.04)	0.3	1.0	2.4	5.4	0.4	1.0	2.5	5.6
$\Delta(r-e)_t$	-3.25 (-3.70)	-3.37 (-3.62)	0.1	1.8	2.9	4.1	0.1	1.9	3.1	4.4
Δa_t	-5.25 (-7.07)	-5.25 (-6.99)	0.0	0.2	0.5	5.2	0.0	0.2	0.6	5.3
Δy_t	-3.91 (-4.51)	-3.91 (-4.45)	1.6	3.3	5.5	7.1	1.7	3.3	5.6	7.2
$\Delta \pi_t$	-2.76 (-4.45)	-2.87 (-4.41)	1.3	2.4	4.1	8.0	1.1	2.4	4.4	8.6
p_t^*	-1.17 (-2.67)	-1.25 (-2.73)	3.2	3.5	5.1	6.6	3.8	4.1	5.9	7.5

[a]Except for c_t and r_t, all variables are percentage changes of quarterly data from 1971 to 1988. c_t = change in domestic credit/monetary base, r_t = change in international reserves/monetary base, e_t = peso price of a U.S. dollar, a_t = money multiplier, y_t = industrial production index, π_t = Mexico's rate of inflation, and p_t^* = U.S. rate of inflation.

[b]ρ is the OLS estimate of ρ and its t-statistic is in parentheses.

[c]For T = 0, the critical values at 10%, 5%, and 1% are -2.58, -2.89, and -3.51 respectively, Fuller (1976), p. 373.

[d]For T = 1, 2,...,72, the critical values at 10%, 5%, and 1% are -3.15, -3.45, and -4.04 respectively, Fuller (1976), p. 373.

[e]For i = 1, 2, 3, 4, LM(i) are the Lagrange Multiplier test statistics proposed by Godfrey (1978) to test for ith order serial correlation, and are distributed as chi-square, χ^2, with 1, 2, 3 and 4 degrees of freedom. The 5% critical values for $\chi^2(1) = 3.84$, $\chi^2(2) = 5.99$, $\chi^2(3) = 7.81$ and $\chi^2(4) = 9.49$.

variables but they first need to be tested for co-integration. Table 3.3 presents the results of estimating the co-integrating regression equation (3.5). In its estimation, several coefficients were held equal to zero, which resulted in five equations, 3.5.1 to 3.5.5. These restrictions were imposed in order to determine whether adding other explanatory variables in the traditional bivariate model (c and (r-e) only) will change the results of the tests for co-integration.

The co-integration tests, reported in Table 3.4, show that, in all five cases, co-integration among these variables cannot be rejected, although from Table 3.3, it appears that some variables such as y_t and p_t^* , are not significant. Table 3.4 also reports the Lagrange multipliers proposed by Godfrey (1978) to test for serial correlation of first, second, third, and fourth order of the DF and ADF tests for co-integration.[19] Those statistical results suggest that no serial correlation is present in the co-integration tests. However, as Phillips and Perron

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[19]The Lagrange multiplier test for serial correlation of order i is constructed by regressing the equation's residuals on both the original regressors and the residuals themselves lagged i times. Next, multiply the number of observations times the coefficient of determination R^2. This will produce a statistic asymptotically distributed as chi-square, χ^2, with i degrees of freedom. Reject the null hypothesis of zero autocorrelation if the Lagrange multiplier statistic is greater than χ^2 at some significance level.

Table 3.3. Co-integrating Regressions with Dependent Variable $(r-e)_t^a$

	Equation Number				
Variable	3.5.1	3.5.2	3.5.3	3.5.4	3.5.5
Constant	-0.116 (-0.49)	-.0059 (-0.27)	-.0715 (3.33)	.059 (2.56)	.0415 (1.05)
c_t	-.7654* (-6.23)	-.8224* (-7.04)	-.5381* (-5.24)	-.5539* (-5.37)	-.5423* (-5.27)
a_t		-.4131* (-3.15)	-.2559** (-2.39)	-.2483** (-2.33)	-.2495** (-2.33)
π_t			-1.1914* (-6.38)	-1.1138* (-5.67)	-1.1163* (-5.46)
y_t				.5671 (1.22)	
p_t^*					1.4929 (0.90)
R^2	.36	.44	.65	.67	.66
DW	1.08	1.40	1.58	1.60	1.63

[a]The co-integration or equilibrium equation (3.5) takes the regression form: $(r-e)_t = -c_t - a_t + y_t - \pi_t + p^*_t + V_t$. Except for r_t and c_t, all variables are percentage changes of quarterly data from the first quarter of 1971 to the second quarter of 1988. c_t = change in domestic credit/monetary base, r_t = change in international reserves/monetary base, a_t = money multiplier, π_t = Mexico's rate of inflation, y_t = industrial production index, p_t^* = U.S. rate of inflation, and V_t is a white-noise error term.

R^2 is the coefficient of determination, and DW is the Durbin-Watson statistic.

t-statistics are in parentheses.

*Significant at 1%.

**Significant at 5%.

Table 3.4. Engle-Granger and Engle-Granger-Yoo Co-integration Tests

Statistic	Equation Number[a] 3.5.1	3.5.2	3.5.3	3.5.4	3.5.5
DF[b]	-4.94*	-5.99*	-6.56*	-6.66*	-6.76*
ADF[c]	-3.10***	-3.29	-3.80***	-3.89	-4.04
PP[d]	-5.18*	-6.04*	-6.30*	-6.32*	-6.43*
DFLM(1)[e]	1.67	5.82	0.21	0.01	0.06
DFLM(2)	2.05	5.76	0.32	0.02	0.31
DFLM(3)	2.76	7.08	0.36	0.18	0.47
DFLM(4)	3.30	12.32	3.47	3.28	3.99
ADFLM(1)[f]	0.46	0.23	0.23	0.18	0.24
ADFLM(2)	0.44	0.77	2.04	1.88	2.11
ADFLM(3)	0.71	3.98	2.33	1.12	2.25
ADFLM(4)	1.09	5.53	4.87	4.14	4.74

The V_t used in the DF, ADF, and PP tests are the residuals from the co-integration regressions of Table 3.3.

[a]Refers to the corresponding equation number of Table 3.3.

[b]The DF 5% critical values for 2 to 5 variables are -3.37, -3.93, -4.22, and -4.58 (Engle and Yoo p. 157).

[c]The ADF 10% critical values for 2 to 5 variables are -2.91, -3.32, -3.71, and -4.06 (Engle and Yoo, p. 157).

[d]Regression equation: $V_t = \mu - \hat{\alpha}V_{t-1} + \epsilon_{vt}$, and test H_0: $\hat{\alpha} = 1$. The PP 1% critical values for 2 to 5 variables are -3.73, -4.22, -4.61, and -4.98 (Engle and Yoo, p. 158).

[e,f]Refer to Lagrange multipliers to test for serial correlation of first to fourth order of the DF and ADF, respectively. The 5% critical values for $\chi^2(1) = 3.84$, $\chi^2(2) = 5.99$, $\chi^2(3) = 7.81$, $\chi^2(4) = 9.49$.

*Significant at 1%.
**Significant at 5%.
***Significant at 10%.

(1988) and Perron (1988) have shown, the DF and ADF tests do not account for possible heteroskedasticity and serial correlation in V_t, the residuals of the co-integration regression. Those authors suggest the use of their Phillips-Perron Test (PP), which was also performed and reported in Table 3.4 (The Phillips-Perron test is discussed in Chapter 4). Again, stationarity of V_t cannot be rejected. Thus, co-integration is supported by all three tests, although the significance level of the ADF tests is lower.

The results of the unit root and co-integration tests provide statistical evidence supporting the existence of a long-run relationship between the growth rates of domestic credit, international reserves, and exchange rates, which is a notion consistent with the long-run monetary model of exchange market pressure. The next step in our Granger causality tests is to estimate an error-correction model.

Tables 3.5 and 3.6 present the results of testing for Granger causality between Δc_t and $\Delta(r-e)_t$ using the error-correction model of equations (3.13) and (3.14). Dummy variables were included to account for the adoption of a flexible exchange rate on September 1, 1976 and for the nationalization of the Mexican banking system on August 31, 1982. The dummy variables were equal to 1 in the third quarter of 1976 and 1982, zero otherwise.

Table 3.5. F-Statistics for Granger-Causality Tests[a]

Regressor[b]	Dependent Variable With Estimated V_{t-1} of: Equation 3.5.1		Equation 3.5.2	
	$\Delta(r-e)_t$	Δc_t	$\Delta(r-e)_t$	Δc_t
$\Delta(r-e)_t$	7.91 (0.00)	3.67 (0.01)	9.88 (0.00)	3.57 (0.01)
Δc_t	5.23 (0.00)	6.43 (0.00)	10.22 (0.00)	6.07 (0.00)
Δa_t			6.26 (0.00)	5.96 (0.00)
λ_1		-.2692** (-1.83)		-.3240* (-2.27)
λ_2	-.2812** (-1.91)		-.2336*** (-1.68)	
FPE[c]	-9.493		-15.823	

[a]F-statistics to test the null hypothesis H_0: all lags of a regressor equal zero.

[b]Definitions of the variables are given in Tables 3.1, 3.2 and 3.3. Numbers under λ_1 and λ_2 are the estimates of the coefficients of the error-correction term, V_{t-1}, the residuals of the corresponding co-integration equation of Table 3.3.

[c]Akaike's final prediction error calculated as suggested by Judge, et al., (1985) p. 687, indicated the lag length of the regressors to be equal to four.

Numbers in parentheses are the significance levels of the F-statistics, but are t-statistics for λ_1 and λ_2.

*Significant at 1%.

**Significant at 5%.

***Significant at 10%.

Table 3.6. F-Statistics for Granger-Causality Tests[a]

Regressor[b]	Dependent Variable With Estimated V_{t-1} of:					
	Equation 3.5.3		Equation 3.5.4		Equation 3.5.5	
	$\Delta(r-e)_t$	Δc_t	$\Delta(r-e)_t$	Δc_t	$\Delta(r-e)_t$	Δc_t
$\Delta(r-e)_t$	5.60 (0.00)	4.72 (0.00)	5.34 (0.00)	5.21 (0.00)	5.73 (0.00)	4.82 (0.00)
Δc_t	4.03 (0.01)	1.29 (0.29)	2.77 (0.05)	1.50 (0.23)	3.58 (0.02)	1.09 (0.36)
Δa_t	1.20 (0.32)	4.12 (0.01)	1.31 (0.28)	5.76 (0.00)	1.02 (0.39)	3.39 (0.03)
$\Delta \pi_t$	0.45 (0.71)	0.88 (0.46)	0.41 (0.75)	1.33 (0.28)	0.41 (0.74)	1.03 (0.38)
Δy_t			0.42 (0.74)	0.88 (0.46)		
Δp^*_t					0.35 (0.78)	0.43 (0.73)
λ_1		-.8696** (-2.38)		-.9287** (-2.41)		-.9913** (-2.51)
λ_2	-.6924** (-1.99)		-.7415** (-1.93)		-.8278** (-2.18)	
FPE[c]	-21.480		-28.932		-31.906	

[a]F-statistics to test the null hypothesis H_0: all lags of a regressor equal zero.

[b]Definitions of the variables are given in Tables 3.1, 3.2, and 3.3. Numbers under λ_1 and λ_2 are the estimates of the coefficients of the error-correction term, V_{t-1}, the residuals of the corresponding co-integration equation of Table 3.3.

[c]Akaike's final prediction error calculated as suggested by Judge, et al., (1985) p. 687, indicated the lag length of the regressors to be equal to three.

Numbers in parentheses are the significance levels of the F-statistics, but are t-statistics for λ_1 and λ_2.

*Significant at 1%.
**Significant at 5%.

Granger tests are sensitive to the regressors' selected lag length. Hence, the lag length was selected by Akaike's final prediction error criterion as presented in Judge, et al. (1985, p. 687).[20] Akaike's results suggested lag lengths of four for the traditional bivariate and three variable models, and three lags for the others.

Now, let us consider the traditional bivariate model with $\Delta(r-e)_t$ and Δc_t only. For the first equation (3.5.1), Table 3.5 shows that indeed statistical evidence exists supporting a bidirectional Granger causality between the percentage changes in domestic credit and in international reserves and the exchange rate. The F-value = 5.23 supports causality from Δc_t to $\Delta(r-e)_t$, while the F-value = 3.67 indicates causality from $\Delta(r-e)_t$ to Δc_t. That is, the lagged values of both $\Delta(r-e)_t$ and Δc_t are statistically significant at the 1% level. Furthermore, this finding does not support the monetary approach to the balance of payments

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[20]The final-prediction-error due to H. Akaike [1969] is described in Judge, et al., and is calculated by finding the value:

$$\text{AIC}(n) = \text{Ln det } (\tilde{\Sigma}_n) + \frac{2 \cdot M^2 \cdot n}{T}$$

where $\tilde{\Sigma}_n$ is an estimate of the residuals covariance matrix of the system, M is the number of the variables in the system, n is the number of lags in the system, and T is the sample size. These AIC(n) values are calculated for different lags. The lag length with the minimum value for AIC(n) is chosen.

and exchange rate of a unidirectional causality from c_t to $(r-e)_t$, nor does it support the assumption that c_t is exogenous. Moreover, this statistical evidence supports the view that Mexico's central bank sterilizes changes in the balance of payments. This finding is consistent with other studies, such as those by Cumby and Obstfeld (1983) and Gupta (1984). The coefficient on the error-correction term -.2812, statistically significant at 5 percent, reveals that approximately 28 percent of the previous quarter's international reserves and/or exchange rate deviation from its long-run value is corrected within each quarter. Likewise, the coefficient on the error-correction term in the Δc_t equation, -.2692, suggests that about 27 percent of the previous quarter's domestic credit deviation from its long-run or equilibrium value will be corrected each quarter.

Next, let us consider the multivariate cases, equations (3.5.2) to (3.5.5). In general, the bidirectional causality found in the bivariate model is also supported by the statistical significance of the F-statistics of the multivariate models. In the $\Delta(r-e)_t$ equations, the F-statistics for the lagged values of Δc_t are significant at the 1 or 5 percent level. In the Δc_t equations, all lagged values of $\Delta(r-e)_t$ are significant at the 1 percent level. The estimates of the coefficients on the error-correction term (λ_1 and λ_2) show no change in their significance level of 5 percent when other variables enter the estimation. However, the size of these estimates increases from less than 30 percent in the traditional bivariate model to more than 80 percent in the model with five variables. Further analysis of the time series involved in the previous discussion can be carried out by using vector autoregressions (VAR) as proposed by Sims (1980a, 1980b). See Chapter 4 for a discussion on VARs.

Given the complicated structure of the coefficients in the equations of VARs, Sims suggested using innovation accounting to interpret them. Innovation accounting refers to measuring the dynamic responses, over time, of one variable to a single unexpected shock in itself or in another variable. Two measurements of the dynamic interactions of VAR are the impulse response functions and the forecast error variance decomposition (see Chapter 4).

The impulse response functions allow us to trace and measure the response of a variable, say $\Delta(r-e)_t$, to innovations in other variables of the system. Figures 3.1 through 3.5 show the reactions of $\Delta(r-e)_t$ to the innovations in Δc_t, Δa_t, $\Delta\pi_t$, Δy_t and Δp_t^* for the 5 models that resulted from the co-integrating equations 3.5.1 through 3.5.5. Those impulse responses show that, ceteris paribus,

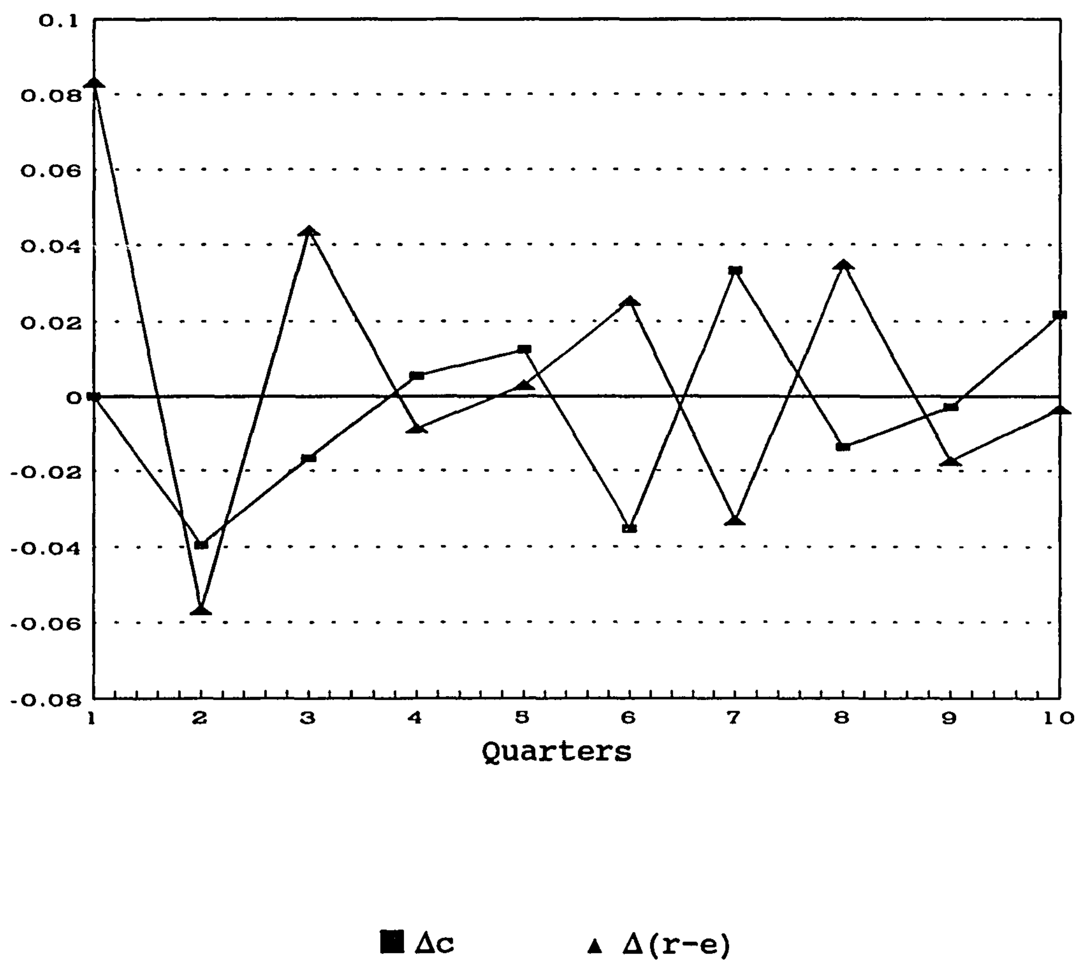

Figure 3.1. Responses of International Reserves and Exchange Rate, "Δ(r-e)" to Unit-shocks

Source: Equation 3.5.1.

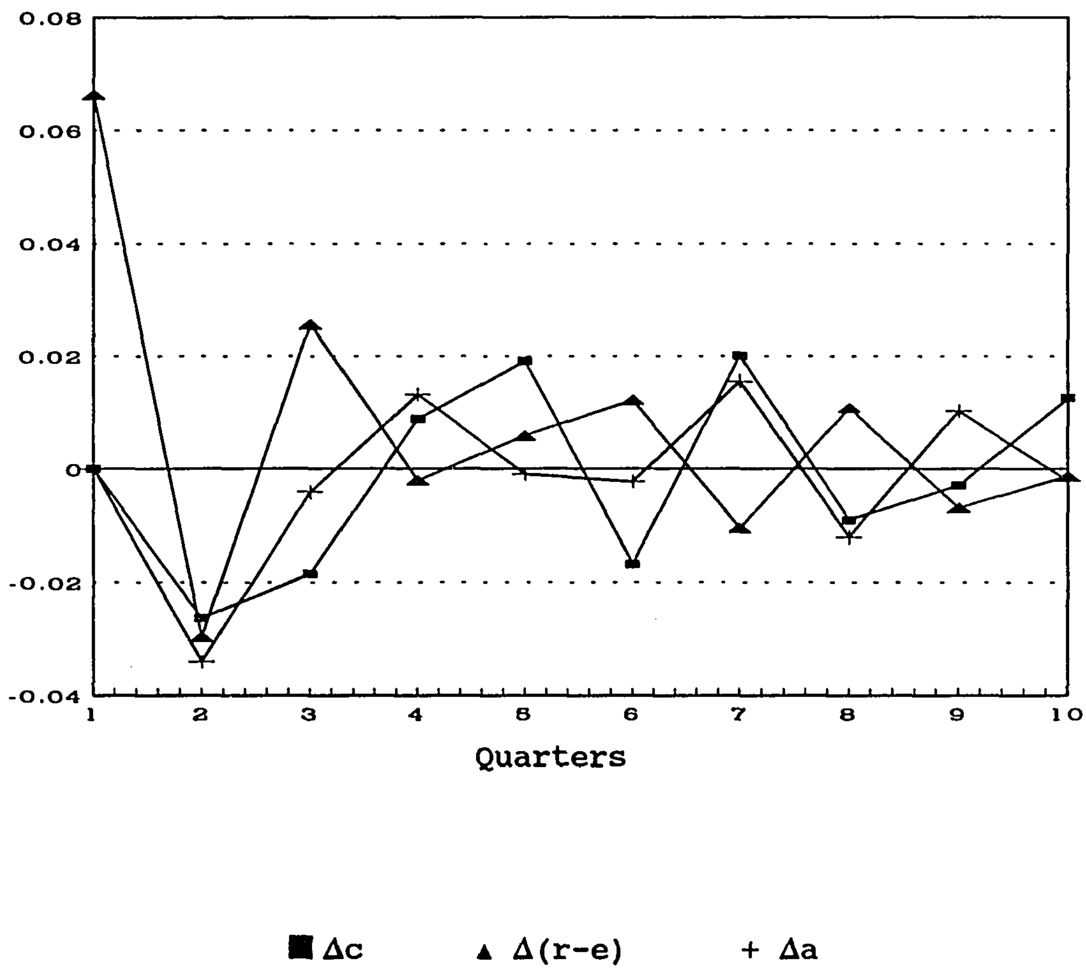

Figure 3.2. Responses of International Reserves and Exchange Rate, "Δ(r-e)" to Unit-shocks

Source: Equation 3.5.2.

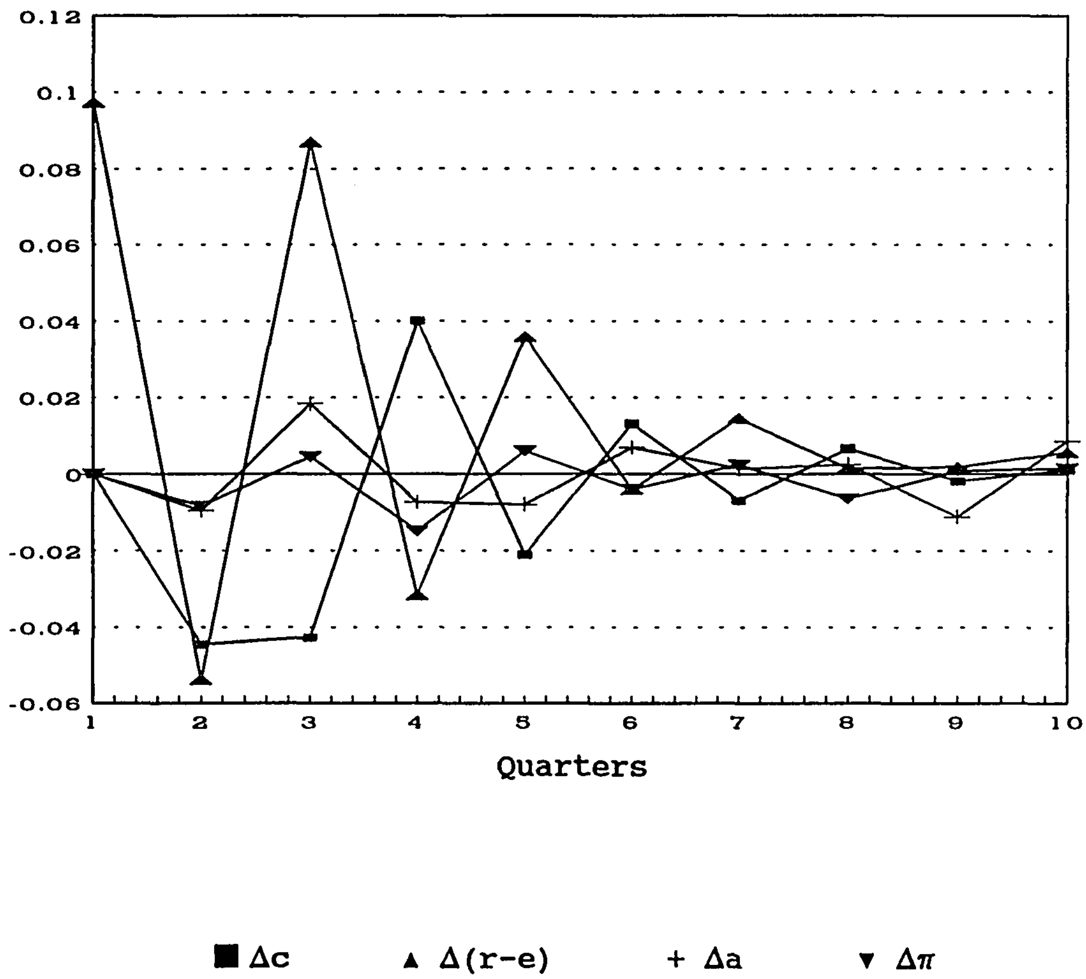

Figure 3.3. Responses of International Reserves and Exchange Rate, "Δ(r-e)" to Unit-shocks

Source: Equation 3.5.3.

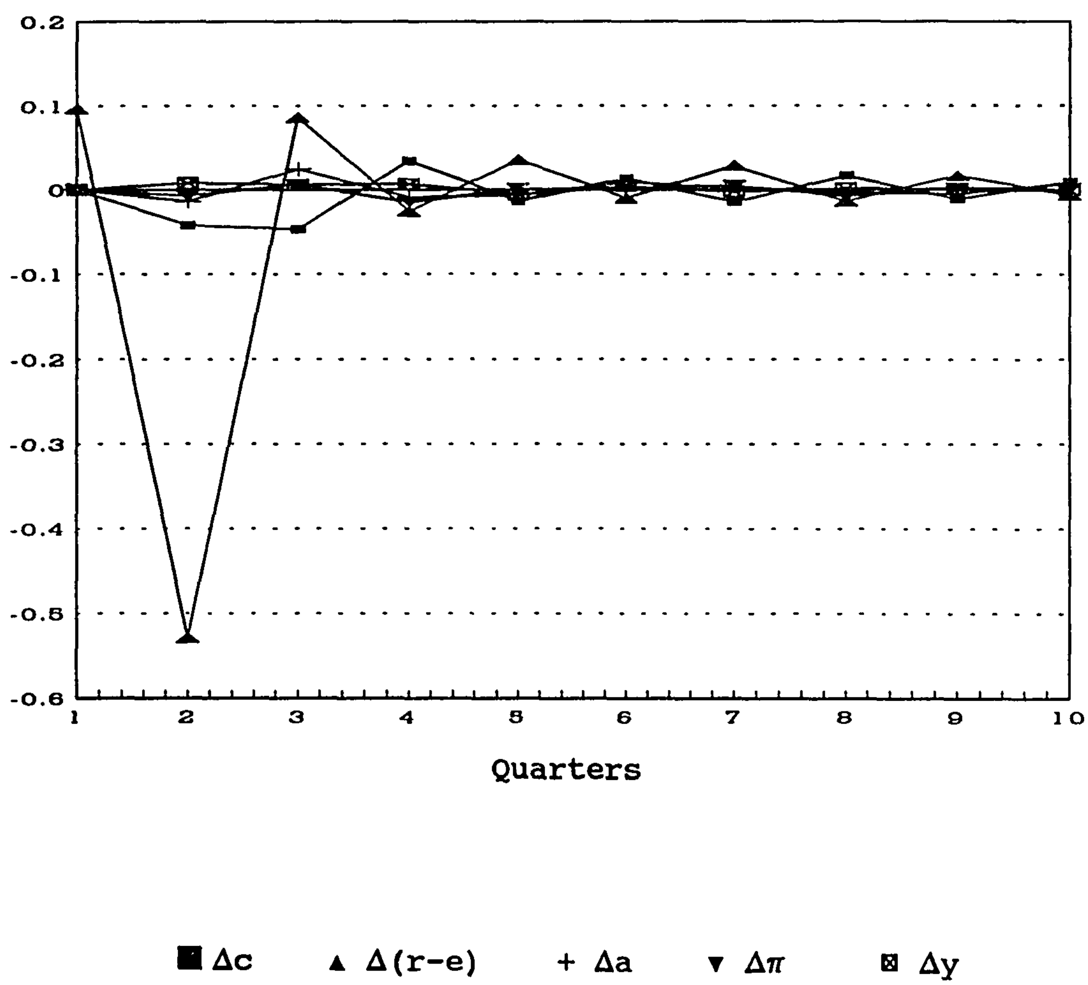

Figure 3.4. Responses of International Reserves and Exchange Rate, "Δ(r-e)" to Unit-shocks

Source: Equation 3.5.4.

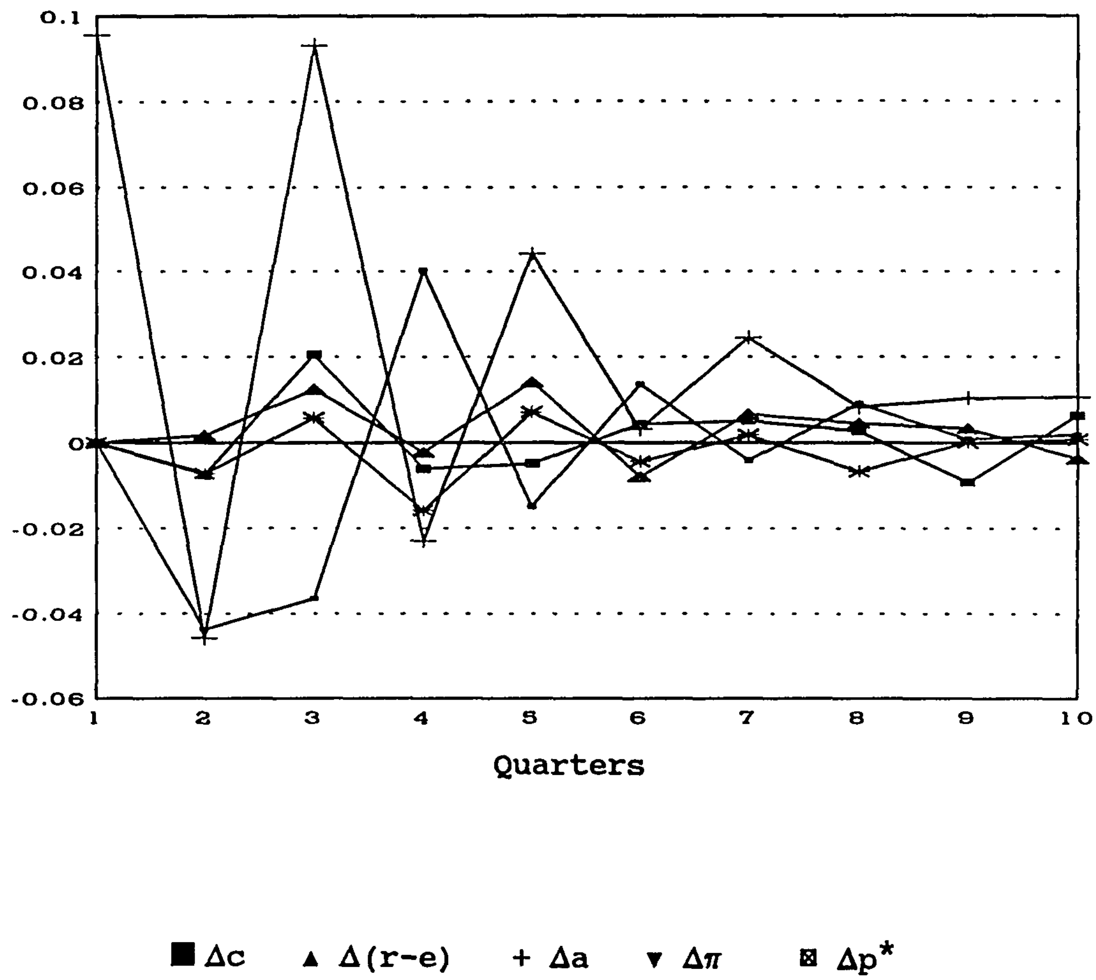

Figure 3.5. Responses of International Reserves and Exchange Rate, "Δ(r-e)" to Unit-shocks

Source: Equation 3.5.5.

an unexpected increase in Δc_t produces international reserves losses, nominal exchange depreciation or a combination of both (e.g. $\Delta(r-e)_t$ falls). Thus, the reaction of $\Delta(r-e)_t$ to a positive unexpected innovation in Δc_t is negative.

Similarly, Figures 3.6 through 3.10 show that the reaction of Δc_t to a positive unexpected shock in $\Delta(r-e)_t$ turns out to be negative as well. Intuitively, an unexpected increase in the change of international reserves (assuming e = 0 in $\Delta(r-e)_t$) will bring about sterilization policies on the part of the authorities that will attempt to offset an increase in Mexico's money supply. This result, together with the F-statistics of Tables 3.5 and 3.6, suggests that the Mexican authorities have followed sterilization policies during the period 1971-1988.

The second measurement of the dynamics of VAR consists of the forecast error variance decomposition. This measurement shows how important an innovation is in explaining the behavior of the variables of the system relative to other innovations (see Chapter 4). Tables 3.7 through 3.11 show the variance decomposition of forecast error of $\Delta(r-e)_t$ and Δc_t for 2, 4, 6, 8, and 10 quarters ahead. These variance decompositions, as in the case of the impulse response functions, refer to the models which

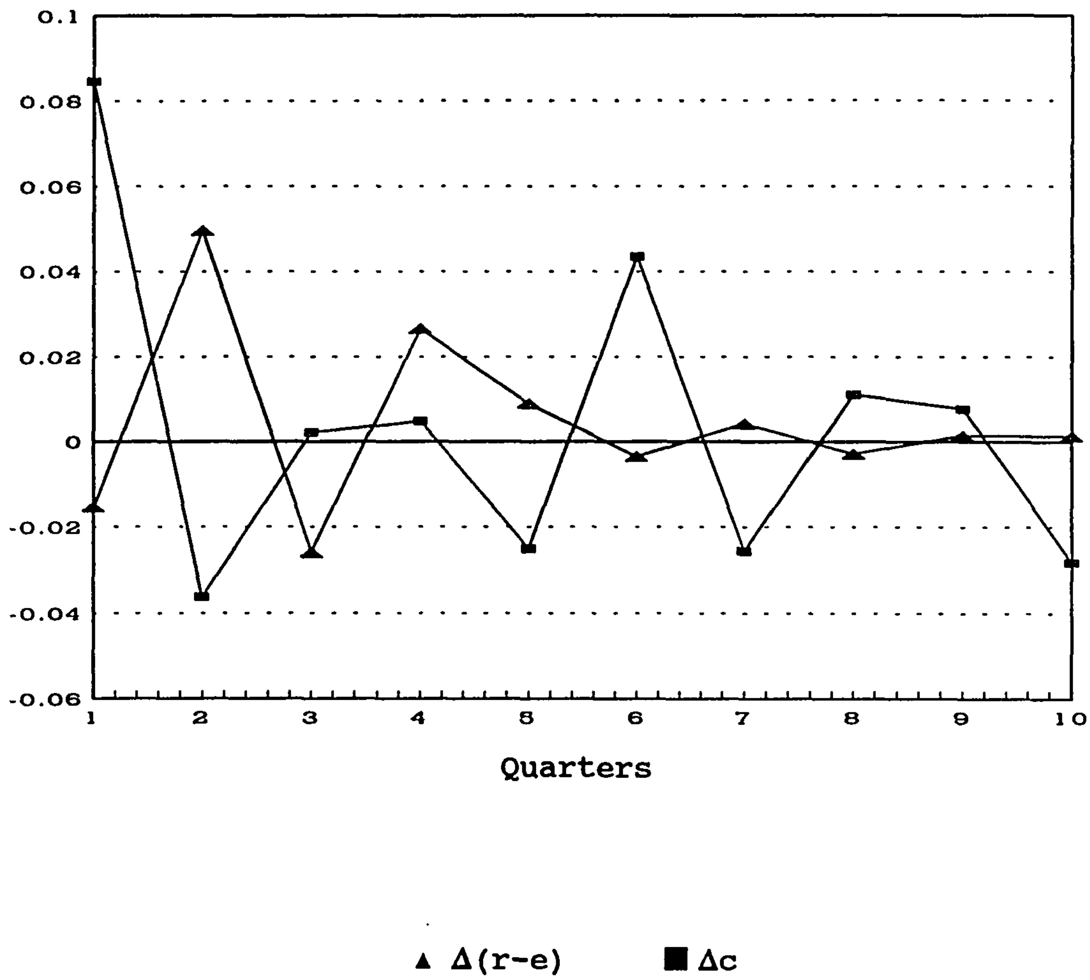

Figure 3.6. Responses of Domestic Credit "Δc" to Unit-shocks

Source: Equation 3.5.1.

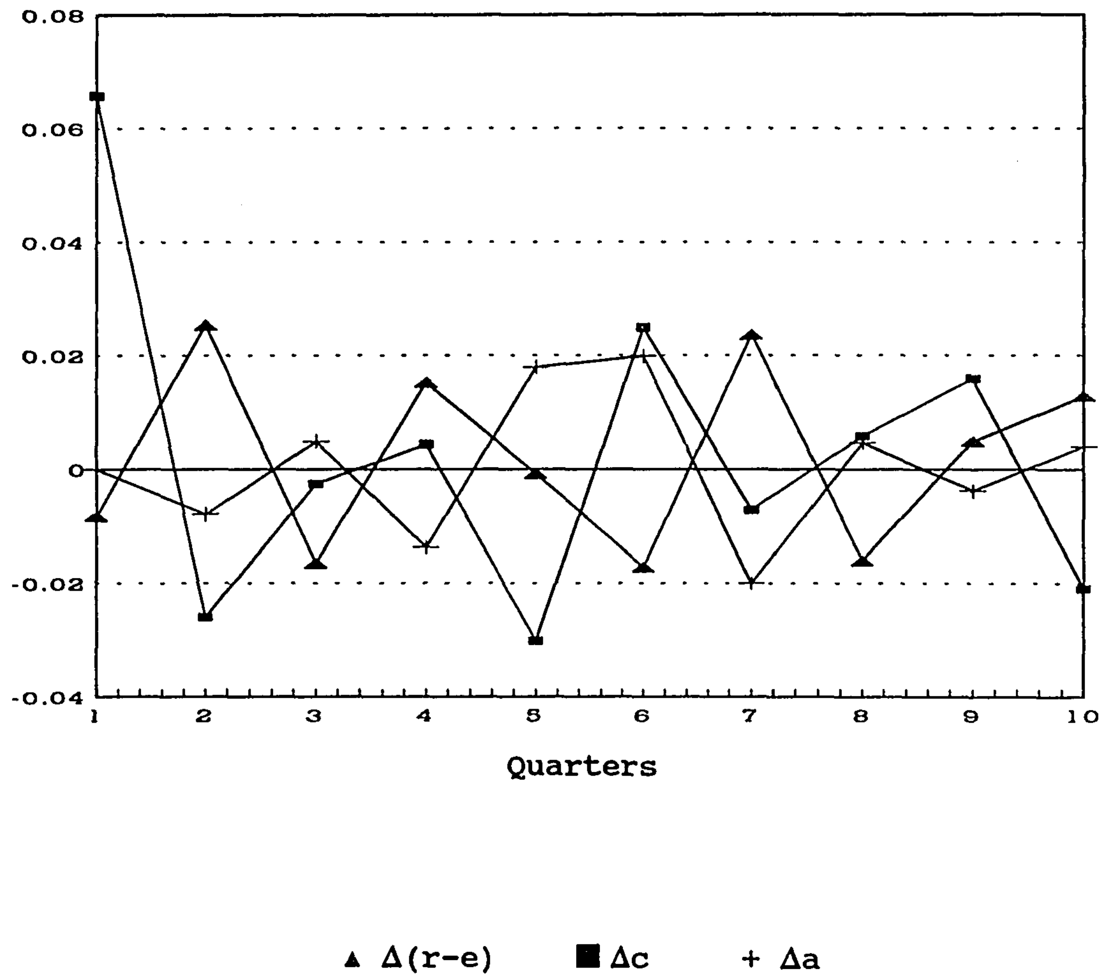

Figure 3.7. Responses of Domestic Credit "Δc" to Unit-shocks

Source: Equation 3.5.2.

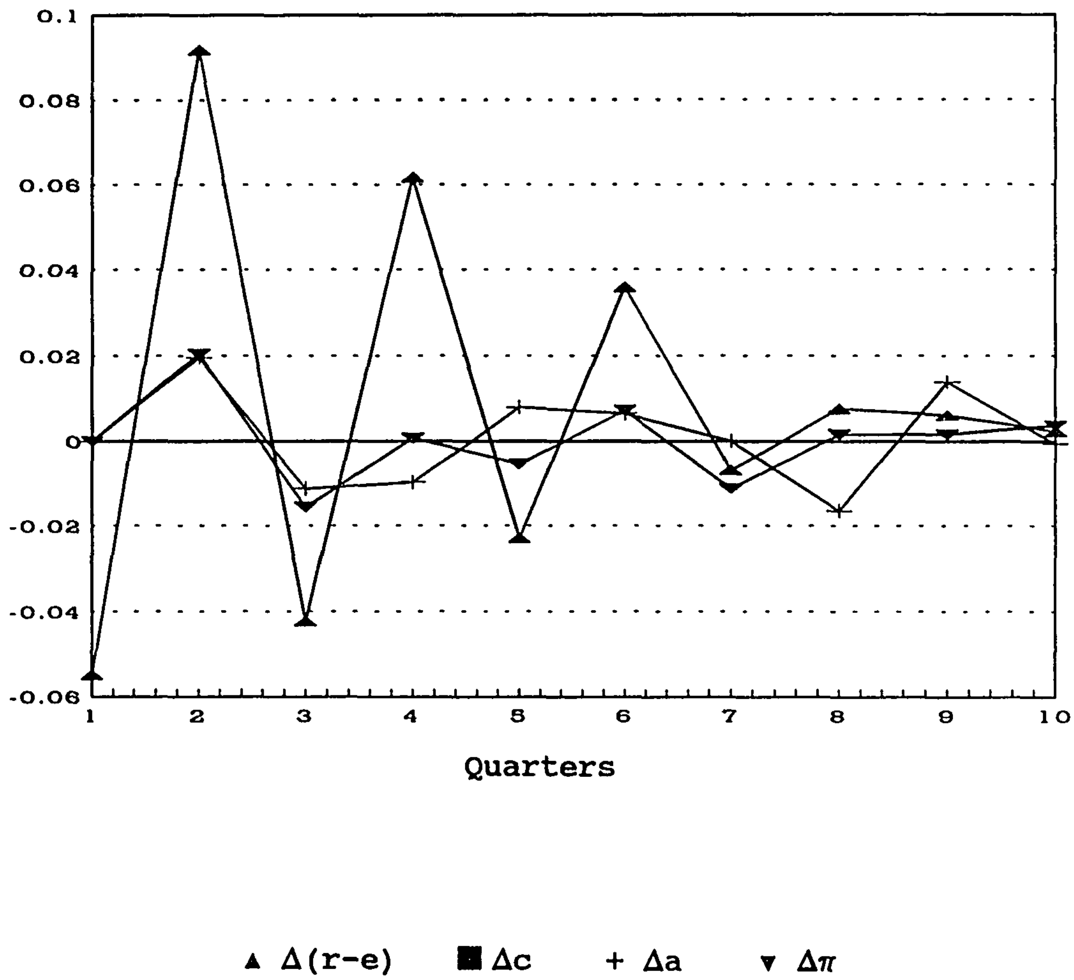

Figure 3.8. Responses of Domestic Credit "Δc" to Unit-shocks

Source: Equation 3.5.3.

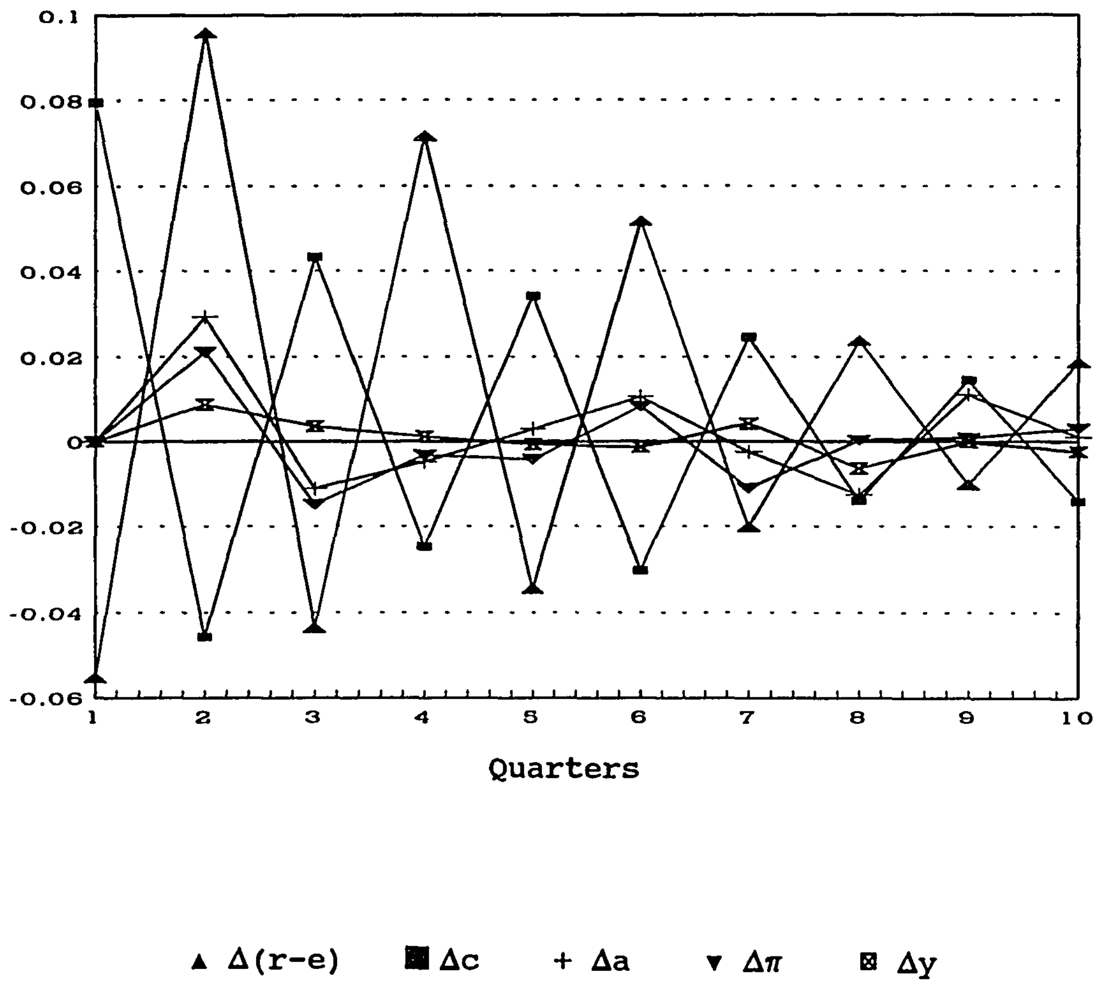

Figure 3.9. Responses of Domestic Credit "Δc" to Unit-shocks

Source: Equation 3.5.4.

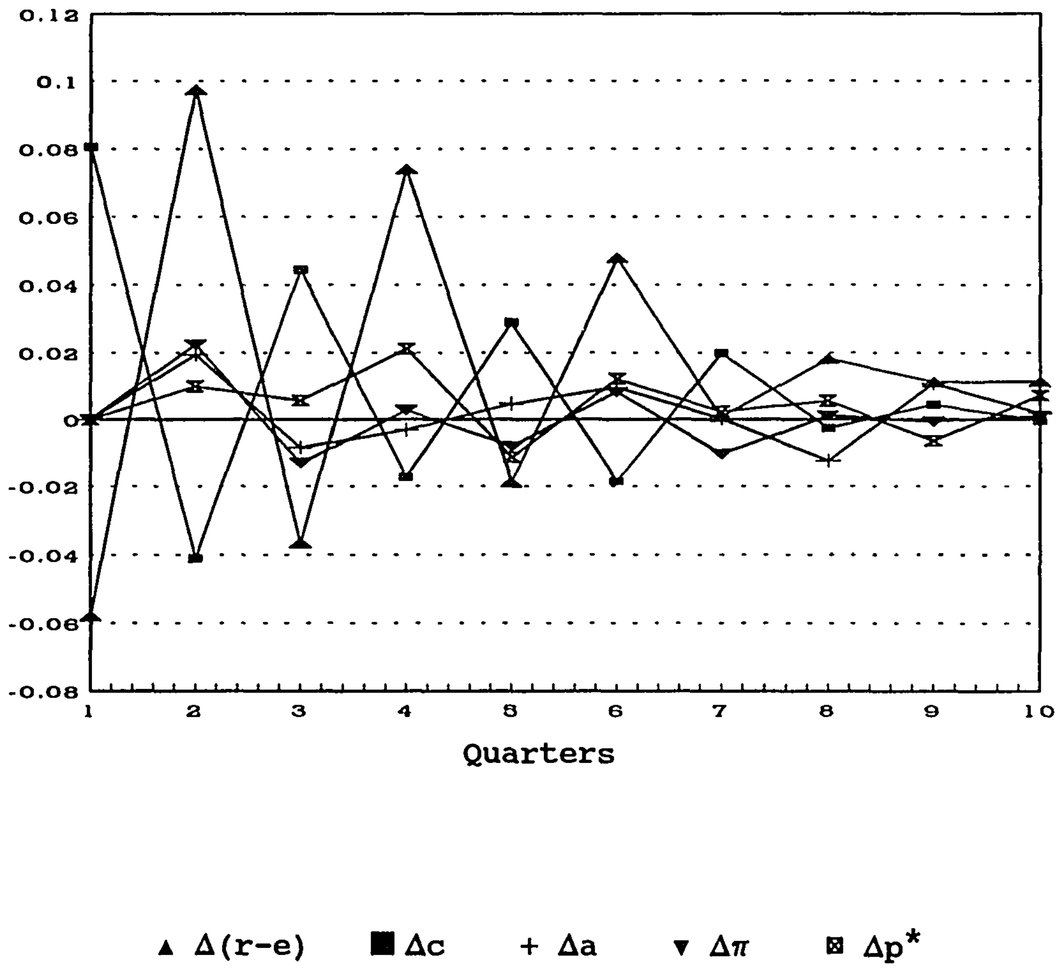

Figure 3.10. Responses of Domestic Credit "Δc" to Unit-shocks

Source: Equation 3.5.5.

resulted from the five co-integrating equations reported in Table 3.3.

Tables 3.7 through 3.11 provide statistical evidence suggesting that both $\Delta(r-e)_t$ and Δc_t are endogenous to the system. For instance, considering the systems with at least four variables (the models that resulted from the co-integration equations 3.5.3, 3.5.4 and 3.5.5), $\Delta(r-e)_t$ explains its own forecast error variance at most 85 percent after two quarters of forecast and 76 percent after 10 quarters of forecast. At the same time, Δc_t explains even less of its own forecast error variance. After two quarters of forecast, Δc_t explains at most 43 percent of its own forecast variance, while after 10 quarters of forecast, it explains at most 38 percent of its own forecast error variance. Recall that a variable is considered exogenous to the system if it explains 100 percent of its own forecast error variance (see Chapter 4).

Furthermore, unit innovations in Δc_t are important in explaining $\Delta(r-e)_t$ as they amount to somewhere between 12 and 20 percent after 2 and 10 quarters of forecast. Moreover, innovations in $\Delta(r-e)_t$ are also important in explaining the forecast error variance of Δc_t, as they amount to at least 50 percent after 2 and 10 quarters of forecast.

Table 3.7. Variance Decomposition of Forecast Error[a]

Forecast Error in	k	Triangular Unit Innovations In $\Delta(r-e)_t$	Δc_t
$\Delta(r-e)_t$	2	86.63	13.37
	4	86.65	13.35
	6	77.63	22.37
	8	75.23	24.77
	10	73.87	26.13
Δc_t	2	25.31	74.69
	4	33.79	66.21
	6	34.15	65.85
	8	41.85	58.15
	10	41.13	58.87

[a] Proportions of forecast error k quarters ahead produced by each innovation. Definitions of variables are given in Table 3.3.

Table 3.8. Variance Decomposition of Forecast Error[a]

Forecast Error in	k	Triangular Unit Innovations In $\Delta(r-e)_t$	Δc_t	Δa_t
$\Delta(r-e)_t$	2	74.09	9.70	16.21
	4	70.73	13.25	16.02
	6	66.33	19.03	14.64
	8	62.25	21.27	16.48
	10	60.85	22.15	16.99
Δc_t	2	11.79	87.16	1.05
	4	17.95	77.99	4.06
	6	16.23	73.13	10.64
	8	21.89	64.82	13.28
	10	21.80	65.69	12.50
Δa_t	2	9.07	28.20	62.72
	4	13.64	33.48	52.87
	6	11.65	29.92	58.43
	8	12.60	29.52	57.88
	10	13.40	25.27	61.33

[a] Proportions of forecast error k quarters ahead produced by each innovation. Definitions of variables are given in Table 3.3.

Table 3.9. Variance Decomposition of Forecast Error[a]

Forecast Error in	k	Triangular Unit Innovations In			
		$\Delta(r-e)_t$	Δc_t	Δa_t	Δp_t
$\Delta(r-e)_t$	2	85.26	13.62	.63	.49
	4	77.16	19.89	1.78	1.17
	6	76.23	20.46	2.04	1.26
	8	76.02	20.52	2.05	1.41
	10	75.52	20.37	2.70	1.41
Δc_t	2	52.93	43.37	1.77	1.93
	4	56.78	38.98	2.03	2.22
	6	56.77	38.83	2.15	2.25
	8	55.70	38.82	2.90	2.58
	10	55.40	38.58	3.44	2.57
Δa_t	2	19.13	14.27	64.23	2.37
	4	29.33	12.09	53.79	4.78
	6	34.01	9.67	52.39	3.93
	8	36.84	9.93	48.64	4.58
	10	37.02	9.31	49.21	4.47
Δp_t	2	39.06	7.20	8.78	44.95
	4	43.08	10.58	8.89	37.45
	6	41.98	10.55	9.79	37.68
	8	41.63	10.41	10.40	37.57
	10	41.34	10.30	11.16	37.20

[a] Proportions of forecast error k quarters ahead produced by each innovation. Definitions of variables are given in Table 3.3.

Table 3.10. Variance Decomposition of Forecast Error[a]

Forecast Error in	k	Triangular Unit Innovations In $\Delta(r-e)_t$	Δc_t	Δa_t	Δp_t	Δy_t
$\Delta(r-e)_t$	2	85.15	12.68	1.39	.36	.42
	4	77.17	17.72	3.37	1.22	.53
	6	76.79	17.83	3.55	1.15	.69
	8	76.09	18.53	3.43	1.27	.69
	10	75.61	18.82	3.61	1.27	.68
Δc_t	2	55.61	38.14	3.88	2.03	.34
	4	60.38	34.08	3.13	2.12	.28
	6	60.77	34.04	2.94	2.01	.24
	8	60.04	34.28	3.20	2.20	.28
	10	59.68	34.44	3.42	2.17	.28
Δa_t	2	24.54	15.19	57.59	2.37	.31
	4	35.58	12.03	45.71	4.47	2.20
	6	36.34	9.20	48.55	3.99	1.91
	8	37.83	8.79	46.36	4.83	2.19
	10	36.85	7.85	48.21	4.64	2.44
Δp_t	2	46.63	6.30	3.89	42.47	.71
	4	47.08	9.92	6.85	33.93	2.22
	6	45.60	10.64	7.01	33.21	3.55
	8	45.08	10.85	7.16	32.88	4.02
	10	44.12	10.59	8.97	32.09	4.22
Δy_t	2	4.45	51.11	8.38	2.95	79.11
	4	25.47	12.13	8.15	4.91	49.34
	6	30.81	18.73	10.10	5.12	35.24
	8	30.99	18.06	12.36	5.17	33.42
	10	31.61	19.07	12.86	5.41	31.05

[a] Proportions of forecast error k quarters ahead produced by each innovation. Definitions of variables are given in Table 3.3.

Table 3.11. Variance Decomposition of Forecast Error[a]

Forecast Error in	k	Triangular Unit Innovations In $\Delta(r-e)_t$	Δc_t	Δa_t	Δp_t	Δp_t^*
$\Delta(r-e)_t$	2	84.84	14.33	.42	.39	.02
	4	77.74	18.44	1.94	1.27	.61
	6	77.16	18.10	1.90	1.39	1.45
	8	77.03	17.88	1.96	1.51	1.62
	10	76.80	17.68	2.35	1.49	1.68
Δc_t	2	58.37	37.17	1.72	2.29	.44
	4	61.76	32.82	1.45	2.15	1.81
	6	61.65	32.14	1.59	2.27	2.35
	8	60.82	32.31	1.96	2.50	2.41
	10	60.71	32.95	2.25	2.47	2.62
Δa_t	2	24.10	16.96	54.13	1.46	3.35
	4	37.57	12.72	38.34	2.94	8.43
	6	41.10	11.18	39.71	2.56	5.46
	8	43.52	11.42	35.73	3.08	6.26
	10	43.31	10.93	37.25	3.03	5.48
Δp_t	2	37.77	8.82	6.65	45.81	.94
	4	42.72	12.06	7.03	37.05	1.14
	6	41.59	11.98	7.81	36.61	2.00
	8	41.38	11.74	8.28	36.03	2.57
	10	41.23	11.64	9.02	35.49	2.61
Δp_t^*	2	2.75	.20	1.30	.73	95.02
	4	2.92	1.19	1.16	1.06	93.68
	6	3.31	1.25	1.34	1.10	93.00
	8	3.48	1.27	1.54	1.20	92.52
	10	3.76	1.31	1.81	1.25	91.87

[a] Proportions of forecast error k quarters ahead produced by each innovation. Definitions of variables are given in Table 3.3.

Overall, the statistical tests conducted on changes in international reserves and exchange rate and changes in domestic credit throughout this section, lend support to the notion that both $\Delta(r-e)_t$ and Δc_t Granger-cause one another and are important in explaining each other's behavior. This notion is supported by the F-statistics for Granger causality reported in Tables 3.5 and 3.6, the impulse response functions of Figures 3.6 through 3.15, and the forecast error variance decompositions reported in Tables 3.7 through 3.11.

Conclusions

Using co-integration and vector autoregressions techniques, the nature of the relationship between domestic credit, international reserves, and the exchange rate embodied in the monetary model of exchange market pressure was studied for Mexico during the first quarter of 1971 to the second quarter of 1988. Tests for co-integration among these variables support the existence of a long-run relationship in the growth rates of domestic credit, the exchange rate, and international reserves -- that is, those variables seem to be co-integrated. In addition, multivariate Granger causality tests, together with innovation accounting, support a bidirectional Granger causality from changes in international reserves and exchange rate to changes in domestic credit, and vice versa. This finding leads to two observations.

First, the notion of the monetary approach of the balance of payments and exchange rate of a unidirectional causality from c_t to $(r-e)_t$ is not supported, nor is the assumption of an exogenous c_t. Second, the statistical support of bidirectional causality indicates that Mexico's monetary authorities adjust domestic assets to neutralize exogenous balance-of-payments deficits on the monetary base. Moreover, the error-correction term suggests that some percentage of the discrepancy between the actual rates and the long-run values of international reserves and the exchange rate, as well as of domestic credit, will be corrected within the next period.

While the results of this chapter are fairly robust in that including more than two variables in the system does not significantly affect the Granger causality tests, the next step in studying these variables might be to construct and estimate a structural model.

The findings of this chapter, together with the fact that Mexico is an open economy with a fixed, or controlled, (crawling-peg) exchange rate system, underline Mexico's dependence on the rest of the world as far as monetary and fiscal policy is concerned.

CHAPTER 4. CO-INTEGRATION AND TESTS OF PURCHASING POWER PARITY: AN EMPIRICAL INVESTIGATION OF MEXICO'S DATA

Introduction

The condition of purchasing power parity (PPP) has been used as a critical building block in many modern models of balance of payments and exchange rate determination.[21] These models have been criticized because, among other things, some empirical evidence supports the existence of large and persistent deviations from PPP.[22] Moreover, deviations from PPP are of short and long-run nature. On the one hand, short-run deviations may be transitory and due to commodity arbitrage failure and measurement error (Bruce and Purvis (1985)); inefficient markets and government

[21]See for instance Rudiger Dornbusch (1984) and Chapter 3 of this dissertation.

[22]The empirical evidence on PPP is mixed and the results obtained depend upon the countries under study, sample periods, and the price indexes used in the econometric work. Surveys on PPP literature can be found in the articles by Lawrence H. Officer (1976), Rudiger Dornbusch (1987) and Peter Isard (1987). Authors whose papers provide support for a long-run PPP include Mark Rush and Steven Husted (1985), Hali J. Edison (1987), and Walter Enders (1988) and (1989). Authors whose papers do not support PPP include Paul R. Krugman (1987), Craig S. Hakkio (1984) and Jacob A. Frenkel (1981).

intervention (Shapiro (1986)); delivery lags (Magee (1978)); and short-run non-neutrality of money (Dornbusch (1976) and Frenkel and Rodriguez (1982)). On the other hand, long-run deviations from PPP may be permanent and due to changes in equilibrium relationships between exchange rates and relative national prices levels. Such deviations, called real disturbances or real shocks, may be due to countries' differences in real wages, productivity, and technology (Sanyal and Jones (1982)).

Furthermore, nominal shocks can result in temporary, but not permanent deviations from PPP. For instance, in the short run, the "overshooting" model shows that an increase in the money supply will cause both real and nominal exchange rate depreciation. In the long run, however, the nominal exchange rate and the price level will change by the same proportion as the change in the money supply bringing the real exchange rate to its long-run level. Thus, money will be neutral in the long run but not in the short run (Dornbusch (1976), and Frenkel and Rodriguez (1982)).

In the case of Mexico, empirical studies of the balance of payments and exchange rate determination are numerous (see Chapter 3). Without exception, all of those studies impose purchasing power parity as an important assumption when building and testing those long-run models. However, studies dealing with tests of PPP using Mexican data are for the most part rare in the literature.

In this chapter, the co-integration techniques developed by Granger (1986) and Engle and Granger (1987), are applied to Mexico's data to test whether PPP holds during the period 1960-1988.[23] The null hypothesis of non co-integration (e.g. PPP does not hold) was rejected in favor of accepting PPP for both the consumer price index and the wholesale price index during 1960-1988. An estimated error-correction model, as proposed by Granger (1986) and Engle and Granger (1987), suggests that Mexican prices and/or the peso price of a U.S. dollar adjusted to maintain PPP during the same period.

Further analysis of the real exchange rate was conducted using vector autoregressions (VAR) techniques. Innovation accounting and Granger causality tests derived from the estimated VAR also support the finding that Mexican prices and/or nominal exchange rate adjust to maintain PPP. This statistical evidence in turn, supports the assumption often made in the literature of international economics, that Mexico is a price taker in world markets.

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[23]Several authors that have employed co-integration techniques to test for PPP include: Richard T. Baillie and David D. Selover (1987); Dean Corbae and Sam Ouliaris (1988); Mark P. Taylor and Patrick C. McMahon (1988); Walter Enders (1988); Walter Enders (1989); Nelson C. Mark (1990); Walter Enders (1991); Peter Kugler and Carlos Lenz (1993); and Yoonbai Kim (1991).

This chapter is organized as follows. The following section presents a discussion on purchasing power parity, co-integration, and vector autoregression techniques. The next section presents the empirical results. Finally, the last section presents some conclusions.

Purchasing Power Parity, Co-integration and Vector Autoregressions

The purchasing power parity condition (PPP) was expressed in Chapter 3 as equation (3.3). Here that equation is reproduced as:

$$P_t = E_t \cdot P_t^* \tag{4.1}$$

where P_t is the domestic price level (Mexico's price level); E_t is the nominal exchange rate defined as the price of a unit of foreign currency in terms of domestic currency (mexican pesos per U.S. dollar); P_t^* is the foreign price level (U.S. price level); and the subscript t refers to time. According to equation (4.1), PPP would hold if Mexican prices adjust to changes in E_t and/or in ΔP_t^* .

To test whether PPP holds, several issues must be addressed. First, since all variables involved are endogenous, there is not a clear-cut solution to selecting the dependent variable to be used in a regression. Second, as shown by West (1988), ordinary least squares estimators of a regression with nonstationary variables are not consistent. Here, this is an important issue since P_t, E_t, and P_t^* as will be shown later on, seem to be nonstationary. These two problems are addressed by applying co-integration techniques as proposed by Granger (1986), and Engle and Granger (1987).

To illustrate co-integration in the context of PPP, let us obtain an alternative formulation of PPP by rewriting equation (4.1) as equation (4.2):

$$P_t - \alpha E_t \cdot P_t^* = \epsilon_{1t} \tag{4.2}$$

where all variables are defined as before, α is a constant and ϵ_{1t} is a stochastic disturbance. Here, PPP will hold if $\alpha = 1$ and ϵ_{1t} is stationary. Now, we can think of these two variables as $P_t = X_{1t}$ and $E_t \cdot P_t^* = X_{2t}$. Following Granger (1986) and Engle and Granger (1987), a pair of variables are co-integrated if the following is satisfied. First, X_{1t} and X_{2t} are integrated of the same order d, i.e., X_{1t} and X_{2t} achieve stationarity after differencing them d times denoted as $X_{1t} \sim I(d)$ and $X_{2t} \sim I(d)$. Second, there exists a constant α ($\alpha \neq 0$) such that the linear combination $Z_t \sim$

I(d-b), b > 0. Consider the following linear combination equation (4.3):

$$X_{1t} + \alpha X_{2t} = Z_t \tag{4.3}$$

Here, having d = b = 1, (i.e., X_{1t} and X_{2t} are both I(1) and $Z_t \sim I(0)$) means that even though X_{1t} and X_{2t} are each nonstationary, (both have an infinite variance), their linear combination Z_t, is stationary. Furthermore, if economic theory suggests a long-run relationship such as PPP, then the statistical relationship, equation (4.3), can be used to test for long-run PPP. Therefore, co-integration between P_t and $E_t \cdot P_t^*$ will suggest, from a statistical point of view, that PPP holds as a stable long-run relationship.

The co-integration tests suggested by Granger (1986) and Engle and Granger (1987) consist of two steps.[24] The first step is to determine the order of integratability of each variable or the value of d. This is equivalent to testing for unit roots in each variable.

Two tests for unit roots which are asymptomatically equivalent are the augmented Dickey-Fuller test (Dickey and Fuller (1979)) and the Phillips-Perron test (Phillips

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[24]Other tests for co-integration include Soren Johansen (1988), James H. Stock and Watson W. Mark (1988), and Nicolaos G. Fountis and David A. Dickey (1989).

(1987), Phillips and Perron (1988), and Perron (1988)). An important assumption of the augmented Dickey-Fuller test (ADF) is that the error term of the ADF regression should be white noise. Alternatively, the Phillips and Perron test (PP) does not make this assumption. Instead, they provide several tests for unit roots which are robust to serial correlation and time-dependent heteroskedasticity. Since the ADF test was discussed in Chapter 3, only the PP will be discussed here.

The Phillips-Perron (PP) test for unit roots on the series X_t requires the estimation of one of the two following ordinary least squares regressions:

$$X_t = \mu^* + \alpha^* X_{t-1} + U_t^* \tag{4.4}$$

$$X_t = \tilde{\mu}^* + \tilde{\beta}(T - \frac{N}{2}) + \tilde{\alpha} X_{t-1} + \tilde{U}_t \tag{4.5}$$

where μ^*, α^*, $\tilde{\mu}$, $\tilde{\beta}$, and $\tilde{\alpha}$ are regression coefficients; T is a linear trend; N is the sample size; U_t^* and $\tilde{U}_t$ are the error terms that could be serially correlated processes with time-dependent variances; and the subscript t refers to time. The main difference between equations (4.4) and (4.5) is that the latter accounts for a time trend while the former does not.

In equation (4.4), the null hypothesis of a unit root, H_0: $\alpha^* = 1$, is tested against the stationarity alternative, H_1: $\alpha^* = 0$, by using the adjusted t-statistic, $Z_{(t\alpha^*)}$, given in Perron (1988) p. 308 line (d). Taking absolute values, reject H_0 if $Z_{(t\alpha^*)}$ is larger than the critical values reported by Fuller (1976) p. 373.

Similarly, in equation (6) the null hypothesis of a unit root with a deterministic trend, H_0: $\tilde{\alpha} = 1$, and the alternative hypothesis of stationarity, H_1: $\tilde{\alpha} = 0$, are tested by using the adjusted t-statistic, $Z_{(t\tilde{\alpha})}$, given by Perron (1988), p. 308 line (h). Again taking absolute values, reject H_0 if $Z_{(t\tilde{\alpha})}$ is larger than the critical values reported by Fuller (1976) p. 373. Next, assuming that all variables are integrated of the same order, step 2 is followed.

Step 2 of the Granger (1986) and Engle and Granger (1987) co-integration test, is to determine whether these variables observe a statistical long-run relationship. This is done by estimating the equilibrium or co-integration equation and then testing the residuals of that regression for stationarity. If the residuals from the co-integrating regression are stationary, then these variables are said to be co-integrated. The co-integration regression takes the form of:

$$E_t \cdot P_t^* = a_0 + qP_t + \epsilon_{2t} \tag{4.6}$$

$$P_t = a_1 + \frac{1}{q} E_t \cdot P_t^* + \epsilon_{3t} \tag{4.7}$$

Notice that equations (4.6) and (4.7) define relative prices in terms of Mexican pesos. These specifications of PPP allow us to observe the behavior of the nominal exchange rate and the foreign price level jointly, in the term $E_t \cdot P_t^*$. Alternatively, relative prices can be expressed in terms of foreign currency, i.e. in U.S. dollars.

Expressing relative prices in U.S. dollars will allow us to observe the behavior of Mexico's price level and its nominal exchange rate together in the same term. In that case, the co-integration regressions take the form of:

$$E_t^* \cdot P_t = b_0 + q^* \cdot P_t^* + \epsilon_{4t} \tag{4.8}$$

$$P_t^* = b_1 + \frac{1}{q^*} E_t^* \cdot P_t + \epsilon_{5t} \tag{4.9}$$

where $E_t^* = 1/E_t$ is the U.S. dollar price of a peso; P_t is Mexico's price level; b_0, b_1 and q^* are constants; P_t^* is the U.S. price level; and ϵ_{4t} and ϵ_{5t} are stochastic disturbances. In this alternative specification, PPP will hold if $q^* = 1$ and ϵ_{4t} and ϵ_{5t} are stationary.

Equation (4.8) is particularly appealing as it shows how Mexico's exchange rate ($1/E_t$) and/or Mexico's price level (P_t) would adjust to changes in the foreign price level (P_t^*). That adjustment would take place regardless of the exchange rate regime. For instance, if Mexico's exchange rate is fixed, (i.e., $E_t = E_{t-1} = E_{t-2} = E_{t-3} = \ldots$) PPP indicates that Mexico and the U.S. would have the same inflation rate. On the other hand, if Mexico's exchange rate regime consists of a flexible or crawling-peg, PPP would predict that Mexico's exchange rate, its price level, or both would adjust to changes in foreign prices. Again, PPP will hold if $E_t^* \cdot P_t$ and P_t^* are co-integrated, e.g. the estimated residuals, ϵ_{2t}, ϵ_{3t}, ϵ_{4t} and ϵ_{5t} are stationary. To test them for unit roots the augmented Dickey-Fuller test, equation (3.12) of Chapter 3 is used. Notice, however, that the critical values used are no longer from Fuller (1976), but from Engle and Yoo (1987).[25]

For the time being, let us assume that the long-run

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[25]After using Monte Carlo techniques Engle and Granger (1987) and Engle and Yoo (1987) have shown that when the X_t are observations from data, the critical values from Fuller (1976) will be appropriate. However, when the X_t are observations from estimated regressions, then Fuller's critical values will be numerically too small which will find co-integration too often. In this case the null hypothesis of no co-integration will be rejected too often.

relationship PPP equation (4.8) exists, or alternatively, let us assume that $E_t^* \cdot P_t$ and P_t^* are co-integrated. That being the case, Granger (1986) and Engle and Granger (1987) have shown that an error-correction specification can be constructed that would take the following form:

$$\Delta E_t^* \cdot P_t = \Phi_0 + \sum_{i=1}^{n} \Phi_{1i} \Delta E_{t-i}^* \cdot P_{t-i} + \sum_{i=1}^{n} \Phi_{2i} \Delta P_{t-i}^* + \lambda_1 V_{t-1} + \omega_{1t} \tag{4.10}$$

$$\Delta P_t^* = \Psi_0 + \sum_{i=1}^{n} \Psi_{1i} \Delta E_{t-i}^* \cdot P_{t-i} + \sum_{i=1}^{n} \Psi_{2i} \Delta P_{t-i}^* + \lambda_2 V_{t-1} + \omega_{2t} \tag{4.11}$$

where $\Delta E_t^* \cdot P_t$ and ΔP_t^* are defined as before; V_{t-1} is the residual from the co-integrating regression; ω_{1t} and ω_{2t} are white-noise error terms; and one of λ_1 or $\lambda_2 \neq 0$. The coefficients of the error-correction terms, λ_1 and λ_2, are expected to be negative and capture the adjustment of

$\Delta E_t^* \cdot P_t$ and ΔP_t^* toward long-run equilibrium. Here the lagged variables in the right-hand side of these equations capture the short-run dynamics of the model. This error-correction model is used to test for Granger causality by testing the statistical significance of the Φ_is and Ψ_is using the standard F-tests.

Further analysis of $E_t^* \cdot P_t$ and P_t^* can be performed by using the vector autoregressions (VAR) techniques proposed by Sims (1980a, 1980b). Let us discuss this VAR technique by following Hakkio and Morris (1984), Falk, Devadoss and Meyers (1986), and Judge, et al., (1988, Chapter 18).

Vector autoregressions are atheoretical models built upon the statistical properties of time series data to explain time series behavior. An advantage of adopting the VAR methodology is that to test specific hypotheses, one does not need to impose prior exogeneity or endogeneity on the model considered. A disadvantage of using this technique is that it is difficult to interpret VAR coefficients as structural parameters. For instance, as Salemi (1986) has shown, if the structural equations and the expectations formations are known, then the VAR coefficients will be non-linear functions of the structural and expectations parameters. Furthermore, if the monetary or fiscal rule changes, then the true values of the VAR parameters will change as well, i.e., the VAR results will be subject to the Lucas (1976) critique. Here, this is not a serious problem since estimation of structural parameters is not the objective of this chapter.[26]

Furthermore, let us assume that the error-correction specification, equations (4.10) and (4.11) can be expressed as a VAR that has 2 stationary stochastic variables and that it can be written as:

$$\begin{bmatrix} \Delta E_t^* \cdot P_t \\ \Delta P_t^* \end{bmatrix} = \begin{bmatrix} A_{11}(L) & A_{12}(L) \\ A_{21}(L) & A_{22}(L) \end{bmatrix} \begin{bmatrix} \Delta E_{t-1}^* \cdot P_{t-1} \\ \Delta P_{t-1}^* \end{bmatrix} + \begin{bmatrix} U_{1t} \\ U_{2t} \end{bmatrix} \quad (4.12)$$

where Δ is the first difference operator i.e., $\Delta X_t = X_t - X_{t-1}$; $E_t^* \cdot P_t$ = Mexico's price level in U.S. dollars; P_t^* = U.S. price level; the subscript t refers to time; A_{ij} are polynomials in the lag operator L; and U_{kt} are white noise stochastic errors (k = 1, 2). The variables

[26]Structural interpretations of VARs can be found in the works by Ben S. Bernanke (1986), Oliver J. Blanchard (1986), and Christopher A. Sims, James H. Stock, and Mark W. Watson (1986). In addition to the difficulty of interpreting the VAR coefficients, further disadvantages of VAR models have been pointed out by others. For instance, Cooley and Leroy (1985) stated that it is not appropriate to use VARs for purposes other than unconditional forecasting. Also, Gordon and King (1982) showed that a given ordering imposes a semi-structure in the model and thus each ordering influences the results of a VAR in a different way.

enter the VAR model in first differences under the assumption that their levels are not stationary but their first differences are.

Furthermore, let us assume that the system (4.12) can be written as the n-th order stationary vector autoregressions, VAR(n):

$$[I - A(L)]X_t = U_t \tag{4.13}$$

where I is the 2x2 identity matrix; $A(L) = A(1)L + A(2)L^2 + \ldots + A(n)L^n$ is a 2x2 matrix of constants polynomial in the lag operator L. X_t is a 2x1 vector of stationary variables such that $X_t' = [\ \Delta E_t^* \cdot P_t \quad \Delta P_t^*\ ]$; U_t is a 2x1 vector of error terms contemporaneously correlated across equations with a finite 2x2 variance-covariance matrix Σ; and the subscript t denotes time. The elements of U_t are also named innovations in that they represent the part of X_t which cannot be predicted linearly from n-lagged values of X_t. Also, notice that the variance-covariance matrix of the error terms, Σ, is a measure of the across equations correlations of the unanticipated changes in each variable.

Given the complicated structure of the coefficients in the equations of the VAR, Sims (1980a, 1980b) suggested using innovation accounting to interpret it.[27] Innovation

[27]See Judge, et al., (1988 p., 751) and Salemi (1986).

accounting refers to measuring the dynamic responses, over time, of one variable to a single unexpected shock in itself or in another variable. Two measurements of the dynamic interactions of VAR are the impulse response functions and the forecast error variance decomposition. Both of these statistics are derived from the moving average representation of equation (4.13).[28]

The impulse response functions will allow us to trace and measure the response of an element of X_t to an innovation of U_t. For instance, using impulse response function we can trace out the response of the Mexican price level in U.S. dollars, $\Delta E_t^* \cdot P_t$, to an unanticipated shock in the foreign price level, U_{2t}. This, however, posits a problem. If the elements of U_t are contemporaneously correlated, then it is unclear what distinguishes an unanticipated foreign price shock from another unanticipated shock, say a shock in $E_t^* \cdot P_t$ itself. Thus it would not make sense to treat U_{1t} and U_{2t} as if they were independent unanticipated shocks in Mexico's price level in U.S. dollars and in U.S. price levels respectively.

To obtain a pure unanticipated or orthogonal shock to

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[28]To ensure that the moving average representation of the system (15) can be obtained, we assume stationarity by supposing that the roots of the characteristic equation, det $[I - A(L)] = 0$, lie outside the unit circle so that $[I - A(L)]$ is invertible.

the system, Sims (1980a, 1980b) suggested decomposing the variance-covariance matrix , Σ, into the product PP′ where P is a 2x2 nonsingular lower triangular matrix comprising, say the choleski decomposition of Σ.[29] Next, premultiply the system by P^{-1}. Thus the system (4.13) can be written as:

$$P^{-1}[I - A(L)]X_t = P^{-1}U_t \tag{4.14}$$

Furthermore, since [I - A(L)] is invertible the system (4.14) can be written as:

$$X_t = B(L)W_t \tag{4.15}$$

where $B(L) = \{[I - A(L)]^{-1}P\}$ such that $B(L) = B(0) + B(1)L + B(2)L^2 + \ldots$; and $W_t = P^{-1}U_t$. System (4.15) is the orthogonalized moving average representation of system (4.13), in which by construction the vector W_t contains mutually orthogonal innovations that are functions of U_t. Next, let us define $W_t = [w_{1t}, w_{2t}]'$. Furthermore, if we define $b_{ij}(s)$ as the i, j-th element of B(s) where i, j = 1, 2 and s = 0, 1, 2 ... then the second element of X_t, the

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[29]This is possible since Σ is symmetric and positive definite. Notice that P, the factorization of Σ, is not unique. Several factorization techniques include: the cholesky decomposition; the Eigen decomposition; and the structural decompositions by Ben S. Bernanke (1986). Also, notice that P, in the cholesky decomposition, will also depend on the ordering of the variables, and therefore a semi-structure is imposed when ordering the variables in the system.

change in the U.S. price level, ΔP_t^*, can be written as:

$$\Delta P_t^* = \sum_{s=0}^{\infty}[b_{21}(s)w_{1t-s} + b_{22}(s)w_{2t-s}] \qquad (4.16)$$

Equation (4.16) shows that the response of ΔP_t^* to current and past shocks or innovations in Mexican prices in U.S. dollars can be characterized by the infinite sequence $b_{21}(s)$, s = 0, 1, 2,.... Furthermore, according to Sims (1980a, 1980b) the $b_{21}(s)$ sequence can be isolated by following the next four steps.

First, set the variables in X_t equal to zero prior to the current period of time (period 0). This means $\Delta E_t^* \cdot P_t$ = 0 for s > 0 or t < 0. Second, let the current innovation in the change of Mexico's prices in U.S. dollars increase by one in period 0, and assume that no further shocks occur. Thus $w_{1t} = 1$, $w_{2t} = 0$, and $w_{1t+s} = w_{2t+s} = 0$ for s > 0. Third, premultiply W_t by P to obtain U_t. Finally, use (4.13) to obtain ΔP_t^*, ΔP_{t+1}^*, ΔP_{t+2}^*, ... , ΔP_{t+k}^*. Here k, a non-negative integer, is the number of quarters ahead for which we want to trace the system's behavior. Thus, by following this procedure we will obtain $\Delta P_{t+s}^* = b_{21}(s)$, while at the same time we would have generated simulated values for the other variable in our model such that $\Delta E_{t+s}^* \cdot P_{t+s} = b_{11}(s)$.

Therefore, $b_{21}(s)$ and $b_{11}(s)$ correspond to the responses of ΔP_t^* and $\Delta E_t^* \cdot P_t$ to an unanticipated orthogonal unit innovation in the change in Mexico's price level in U.S. dollars, (i.e., $W_{1t} = 1$). Moreover, $b_{21}(k)$ is defined as the k step-ahead impulse response of ΔP_t^* to an orthogonal unit innovation in Mexico's price level in U.S. dollars. The remaining impulse responses functions to shocks or innovations in the other variables (the other elements of B(L)) can be obtained by following the four steps already described.

In general, $b_{ij}(k)$ will be the k-step-ahead impulse response function of a variable i to an orthogonal unit shock in the variable j. Furthermore, as Falk, Devadoss and Meyers (1986) point out, the shape of the discrete function $b_{21}(s)$ provides information about the direction and timing of the behavior of the change in U.S. price level (ΔP_t^*) in response to a unit shock in the change in Mexico's price level ($w_{1t} = 1$). The relative importance of this shock or innovation in explaining the actual behavior of ΔP_t^* can be determined by Sims' second statistic, namely, the forecast error variance decomposition of the k-step forecast described by equation (4.17):

$$d_{21}(k) = 100\{\sum_{s=0}^{k} b_{21}^{2}(s)/[\sum_{j=1}^{2} \sum_{s=0}^{k} b_{2j}^{2}(s)\} \quad (4.17)$$

where $\sum_{j=1}^{2} \sum_{s=0}^{k} b_{2j}^{2}(s)$ is the total k-step-ahead forecast variance of ΔP_t^* . Thus the forecast error variance decomposition, equation (4.17), is meant to show how much of the total k step-ahead variance in ΔP_t^* is caused by an orthogonal innovation in the change in Mexico's price level expressed in U.S. dollars (w_{1t}). The closer the forecast error variance decomposition is to 100 percent, the more important are Mexico's price level innovations, relative to other innovations, in explaining U.S. price level movements (ΔP_t^*). In addition the forecast error variance decomposition can be used to measure the degree to which a variable is considered exogenous with respect to a set of variables. A series is considered exogenous if 100 percent of the forecast error variance decomposition is due to an innovation in the series itself. For instance, if an innovation in ΔP_t^* (say w_{2t}), explains close to 100 percent of the forecast error variance decomposition of ΔP_t^* itself, then ΔP_t^* will be considered exogenous to this system.

In this PPP model, if the U.S. is a large country relative to Mexico (in the sense that the U.S. is a price setter in world markets), unexpected innovations in its own price level changes (w_{2t}) would explain most of the forecast error variance of ΔP_t^* . This implies that ΔP_t^* is exogenous to our system. Moreover, assuming that Mexico is a small country (in the sense that it is a price taker in world markets), an unexpected innovation in Mexico's price level expressed in U.S. dollars (w_{1t}) will not explain a relatively large proportion of the forecast error variance of the U.S. price level (ΔP_t^*). The next section presents the empirical results.

Empirical Results

In this section the results of testing for stationarity in the real exchange rate or equivalently, testing for co-integration between $\Delta E_t^* \cdot P_t$ and ΔP_t^* are reported. In this specification of PPP, equation (4.8), the relative prices of both the U.S. and Mexico are expressed in U.S. dollars. This facilitates the interpretation of PPP as it allows us to observe how changes in U.S. prices affect movements in Mexico's price level and/or its nominal exchange rate regardless of the exchange rate regime. This is particularly important because if the nominal exchange rate is fixed, then equation (4.8) will predict that Mexico and the U.S. will have the same inflation. On the other hand, if the exchange rate is not fixed, but say is a crawling-peg, then equation (4.8) will predict that movements in U.S. price level will bring about changes in Mexico's price level, in its nominal exchange rate or both. Moreover, assuming that Mexico is a small country (in the sense that it is a price taker in world markets) equation (4.8) predicts that movements in Mexico's price level in U.S. dollars will have no effect on U.S. price level changes.

The empirical investigation is conducted by dividing the period from the first quarter of 1960 to the second quarter of 1988 into two periods. The first period includes data from the first quarter of 1960 to the second quarter of 1976, a period in which Mexico adopted a fixed exchange rate regime throughout. The second period is from the third quarter of 1976 to the second quarter of 1988. During most of this period Mexico abandoned the fixed exchange rate regime and adopted a crawling-peg system. This period was selected because: a) data prior to 1960 are unavailable and b) Mexico experienced structural changes after the second quarter of 1988 that made the management of its fiscal and monetary policies much different than in prior years.

The data were taken from the International Financial Statistics of the International Monetary Fund. The series were quarter averages of monthly observations of Mexico's consumer price index, P_t=line 64; U.S. consumer price index, P_t^* = line 64; and the nominal exchange rate defined as the peso price of a U.S. dollar, E_t = line rf. To construct $E_t^* \cdot P_t$, where $E_t^* = 1/E_t$, the nominal exchange rate and Mexico's consumer price index were normalized to 1 in the first quarter of 1960. Likewise, P_t^* was normalized to 1 in the same period. In addition, wholesale price indices were used in the estimation as an alternative measure of price levels, in place of consumer price indices.

The unit root tests were performed by estimating the Augmented Dickey-Fuller and the Phillips-Perron equations for P_t^*, $E_t^* \cdot P_t$, ΔP_t^*, and $\Delta E_t^* \cdot P_t$. The results of these tests, reported in Tables 4.1 and 4.2, indicate that P_t^* and $E_t^* \cdot P_t$ are nonstationary while their first differences, ΔP_t^* and $\Delta E_t^* \cdot P_t$ are stationary, e.g. both series are integrated of the same order 1. Further unit root tests which consider structural breaks also support the same conclusion (Perron's unit root tests that account for structural breaks in the time series are reported in Appendix A). Before commenting on the co-integration tests, let us consider the following.

From April of 1954 to August of 1976, Mexico's monetary authorities maintained a fixed exchange rate of 12.50 pesos per dollar. Since September of 1976, the nominal exchange rate has be under crawling-peg regime (see Chapter 2).

Table 4.1. Augmented Dickey-Fuller Unit Root Tests

X_t^a	Consumer Price Index[b] ρ^d		Wholesale Price Index[c] ρ^d	
	No Trend[e]	Trend[f]	No Trend[e]	Trend[f]
$E_t^* \cdot P_t$	-.0097 (-.62)	-.1095 (-2.45)	.3441 (3.52)	-.1037 (-2.61)
$\Delta E_t^* \cdot P_t$	-1.0787 (-4.87)	-1.1076 (-4.83)	-.8932 (-4.98)	-.8919 (-4.95)
P_t^*	.0019 (.83)	-.0066 (-1.91)	-.0005 (-.21)	-.0146 (-2.08)
ΔP_t^*	-.1086 (-2.10)	-.2222 (-2.99)	-.2549 (-2.90)	-.3047 (-3.16)

[a]Data are quarterly averages of monthly observations from the first quarter of 1960 to the second quarter of 1988. E_t^* = U.S. dollar price of a Mexican peso; P_t = Mexico's price level; P_t^* = U.S. price level. All variables were normalized to 1 in the first quarter of 1960. The sample consists of 114 observations to estimate:

$$\Delta X_t = \mu_0 + \mu_1 T + \rho X_{t-1} + \sum_{i=1}^{n} \gamma_i \Delta X_{t-i} + \epsilon_{xt}$$

[b]The consumer price index data were used as the price levels P_t and P_t^*.

[c]The wholesale price index data were used as the price levels P_t and P_t^*.

[d]ρ is the OLS estimate of ρ and its t-statistic is in parentheses.

[e]Assuming T = 0, the critical values at 10%, 5%, and 1% are -2.58, -2.89, and -3.51 respectively, Fuller (1976), p. 373.

[f]Assuming T = 1, 2,...,114, the critical values at 10%, 5%, and 1% are -3.15, -3.45, and -4.04 respectively, Fuller (1976), p. 373.

Table 4.2. Phillips-Perron Unit Root Tests

X_t^a	α^*	$\tilde{\alpha}$	$Z(t\alpha^*)^b$	$Z(t\tilde{\alpha})^c$
		Consumer Price Index[d]		
$E_t^* \cdot P_t$	.9883	.9259	-1.04	-2.75
$\Delta E_t^* \cdot P_t$	.4070	.4075	-6.56	-6.57
P_t^*	1.0122	.9849	2.48	-1.82
ΔP_t^*	.8405	.7388	-3.05	-4.15
		Wholesale Price Index[e]		
$E_t^* \cdot P_t$	.9902	.9310	-.93	-2.64
$\Delta E_t^* \cdot P_t$	.3904	.3898	-6.92	-6.79
P_t^*	1.0065	.9774	.59	-2.05
ΔP_t^*	.7062	.6813	-4.63	-4.94

[a]Data are quarterly averages of monthly observations from the first quarter of 1960 to the second quarter of 1988. E_t^* = U.S. dollar price of a Mexican peso; P_t = Mexico's price level; P_t^* = U.S. price level. All variables were normalized to 1 in the first quarter of 1960. The sample consists of 114 observations to estimate:

$$X_t = \mu^* + \alpha^* X_{t-1} + U_t^*$$

$$X_t = \tilde{\mu}^* + \tilde{\beta}(T - \frac{N}{2}) + \tilde{\alpha} X_{t-1} + \tilde{U}_t$$

[b]Critical values at 10%, 5%, and 1% are -2.58, -2.89, and -3.51 respectively, Fuller (1976), p. 373.

[c]Critical values at 10%, 5%, and 1% are -3.15, -3.45, and -4.04 respectively, Fuller (1976), p. 373.

[d]The consumer price index data were used as the price levels P_t and P_t^*.

[e]The wholesale price index data were used as the price levels P_t and P_t^*.

To account for these two exchange rate regimes, the co-integration regressions were estimated using three samples: one from the first quarter of 1960 to the second quarter of 1988, another from the first quarter of 1960 to the second quarter of 1976, and the third sample from the third quarter of 1976 to the second quarter of 1988.

Table 4.3 reports the co-integration regressions to test for PPP and both the augmented Dickey-Fuller and the Phillips-Perron unit root tests conducted on the estimated residuals of the PPP co-integration regressions. Equations 4.3.1, 4.3.3, and 4.3.5 were estimated with the consumer price index as the price levels (P_t and P_t^*), while the remaining equations included the wholesale price index. Except for Equation 4.3.3, the ADF test provides statistical evidence of co-integration between $E_t^* \cdot P_t$ and P_t^* in all cases. The Phillips-Perron tests support co-integration only for Equations 4.3.2 and 4.3.4. Next, assuming that $E_t^* \cdot P_t$ and P_t^* are co-integrated, an error-correction model was estimated using wholesale prices as the price levels and equations (4.10) and (4.11) as benchmark specifications.

Using the estimated residuals of equations 4.3.2, 4.3.4 and 4.3.6, various error-correction models were estimated following the vector autoregressions (VAR) technique described in the previous chapter. Relative prices entered the VAR in first differences, i.e. $\Delta E_t^* \cdot P_t$ and ΔP_t^*. To explain changes

Table 4.3. Co-Integration Regressions and Tests[a]

Equation[b]		Coefficients of Constant	P_t^*	R^2	ADF[c]	$Z_{(t\hat{\alpha})}$[d]
		First Quarter 1960 to Second Quarter 1988				
4.3.1	$E_t^* \cdot P_t$	.4878 (5.05)	.7707 (19.35)	.7697	-3.64	-2.75
4.3.2	$E_t^* \cdot P_t$	.2204 (3.08)	.9343 (27.6)	.8718	-4.19	-3.21
		First Quarter 1960 to Second Quarter 1976				
4.3.3	$E_t^* \cdot P_t$	-.6203 (-11.50)	1.5936 (38.43)	.9584	-1.03	-1.24
4.3.4	$E_t^* \cdot P_t$	-.2750 (-11.16)	1.3468 (67.45)	.9861	-3.64	-2.97
		Third Quarter 1976 to Second Quarter 1988				
4.3.5	$E_t^* \cdot P_t$	1.6624 (4.26)	.3946 (3.19)	.1816	-2.94	-2.19
4.3.6	$E_t^* \cdot P_t$	.7867 (1.80)	.7376 (4.93)	.3460	-2.90	-2.24

[a]The OLS residuals of the co-integrating regression, V_t, are used in the co-integration tests. Data are quarterly averages of monthly observations. E_t^* = U.S. dollar price of a Mexican peso; P_t = Mexico's price level; P_t^* = U.S. price level. All variables were normalized to 1 in the first quarter of 1960. R^2 is the coefficient of determination.

[b]Equations 4.3.1, 4.3.3, and 4.3.5 were estimated with the consumer price index as the price levels (P_t and P_t^*), while the remaining equations included the wholesale price index in the estimation.

[c]Augmented Dickey-Fuller statistics to test the null hypothesis H_0: V_t is nonstationary in:

$$\Delta V_t = -\phi V_{t-1} + \sum_{i=1}^{4} \delta_i \Delta V_{t-i} + \epsilon_{vt}.$$

The 10% critical values for 50, 100 and 150 observations are -2.90, -2.91 and -2.98, Engel and Yoo (1987) p. 158.

[d]Phillips-Perron statistics to test the null hypothesis H_0: V_t is nonstationary in $V_t = \hat{\alpha} V_{t-1} + \hat{U}_t$. The 10% critical values for 50, 100 and 150 observations are -2.90, -2.91 and -2.98, Engle and Yoo (1987) p. 157.

in Mexico's price level in U.S. dollars ($\Delta E_t^* \cdot P_t$), the lagged change in U.S. price level (ΔP_t^*) was tested by performing Granger causality tests. In addition, impulse response functions and variance decompositions were used to trace the behavior of movements in Mexico's price level.

Assuming that each single equation of the system (4.12) has serially uncorrelated disturbances and has also the same number of explanatory variables, Ordinary Least Squares (OLS) applied to each equation will result in an asympotmatically efficient estimator of A(L), that is equivalent to the Generalized Least Squares Estimator (Judge, et al. (1988) p. 756). Using PC RATS by Doan (1988), system (4.12) was estimated by applying OLS to each regression which included one lag of $\Delta E_t^* \cdot P_t$ and ΔP_t^* ; a constant; the lagged residuals of the corresponding co-integration regression (i.e. regressions 4.3.2, 4.3.4 and 4.3.6); and two dummy variables with values of one in August 1976 and 1982, zero otherwise. To determine the order of A(L) Akaike's method, as in Judge et al., (1988 p. 761), was used.[30]

Many of the interactions among $\Delta E_t^* \cdot P_t$ and ΔP_t^* are contemporaneous. In a VAR these interactions are captured by the correlations among residuals or innovations.

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[30]The final-prediction-error due to H. Akaike (1969) is described in footnote 20.

Table 4.4. Correlation Matrix of the Contemporaneous Disturbances[a]

	$\Delta E_t^* \cdot P_t$	ΔP_t^*
	First Quarter 1960 to Second Quarter 1988	
$\Delta E_t^* \cdot P_t$	1.00	.1907
ΔP_t^*		1.00
	First Quarter 1960 to Second Quarter 1976	
$\Delta E_t^* \cdot P_t$	1.00	.3316
ΔP_t^*		1.00
	Third Quarter 1976 to Second Quarter 1988	
$\Delta E_t^* \cdot P_t$	1.00	.4037
ΔP_t^*		1.00

[a]Computed from the least squares residuals from the estimated error-correction models using the lagged residuals of the co-integration regressions, equations 4.3.2, 4.3.4, and 4.3.6. Data are quarterly averages of monthly observations. E_t^* = U.S. dollar price of a Mexican peso; P_t = Mexico's price level; P_t^* = U.S. price level. All variables were normalized to 1 in the first quarter of 1960.

Table 4.4, the correlation matrix of contemporaneous residuals, shows that innovations in Mexico's price level are positively correlated to innovations in the U.S. price level. That correlation appears to be larger for the period from the third quarter of 1976 to the second quarter of 1988 (equal to .4037). The positive correlation between innovations in $\Delta E_t^* \cdot P_t$ and ΔP_t^* suggest that an unexpected increase in U.S. prices would bring about an increase in Mexico's price level.

Another use of the correlation matrix of contemporaneous disturbances, Table 4.4, is to determine whether a given ordering of variables has important implications for the interpretation of a VAR model. This is because Cholesky's method of orthogonalizing innovations is based on these contemporaneous correlations. Consequently, by reordering the rows and columns of Σ, we will obtain a different factorization matrix. Note, however, that if the contemporaneous residuals or innovations are not correlated, then any particular ordering will not make any difference, since no variance will be explained by other variables of the system. So, is there a criterion to follow when choosing a particular ordering in the system? Indeed there is. Given that P (the Cholesky matrix decomposition of Σ) is lower triangular, one should order the variables so that the most exogenous variable appears before the less exogenous variable, with the most endogenous variable placed last. This is because w_{1t}, the orthogonal shock of the first variable in the ordering (the most exogenous), will immediately affect all the other variables in the system while ΔP_t^*, the last variable in the ordering, will immediately be affected by innovations from any other variable in the system.

Moreover, we could assume that Mexico's price level is the most endogenous and place it last. However, no such assumption is made, in which case two orderings were adopted. First $\Delta E_t^* \cdot P_t$ and ΔP_t^*, and then we reverse it.

Notice, however, that the F-statistics to test for Granger causality are not sensitive to a particular ordering of variables. This is because, once the system is estimated the F-statistics are calculated before orthogonalizing Σ.

Table 4.5 provides statistical evidence that changes in Mexico's price level in U.S. dollars ($\Delta E_t^* \cdot P_t$) are Granger caused by changes in U.S. price levels (ΔP_t^*). This is supported by the F-statistics which are all significant at the 1 percent level. This implies that the null hypothesis that the lagged ΔP_t^* is equal to zero is rejected at the 1 percent level, e.g. lagged ΔP_t^* appears to be statistically different from zero. As shown by Table 4.5, the F-statistics are 6.95, 3.86, and 4.86 for the periods 1960-1988, 1960-1976, and 1976-1988 respectively.

Next, let us consider the results of the estimation with an ordering that assumes $\Delta E_t^* \cdot P_t$ to be endogenous (i.e., ordering ΔP_t^* first then $\Delta E_t^* \cdot P_t$). The last two columns of Table 4.6 show the variance decomposition of forecast error 2 to 10 quarters ahead produced by unit innovations in U.S. price changes (ΔP_t^*) and in Mexico's price movements ($\Delta E_t^* \cdot P_t$). Table 4.6 provides statistical evidence that innovations in U.S. prices (ΔP_t^*) help explain the forecast error variance of Mexico's price level movements ($\Delta E_t^* \cdot P_t$). For instance, unit innovations in ΔP_t^* explain between 10.52 percent to 17.10 percent of the forecast error of $\Delta E_t^* \cdot P_t$ during the period 1960-1988. During 1960-1976 that proportion decreased to somewhere between 8 percent and 12 percent, while during 1976-1988 that percentage rose, e.g. during the period 1976-1988, unit innovations in ΔP_t^* account for somewhere between 27.39 percent to 46.09 percent of the forecast error variance of $\Delta E_t^* \cdot P_t$.

Moreover, information provided in Table 4.6 suggests that U.S. price movements are exogenous to the system. That ΔP_t^* is exogenous to this system is supported by its variance decomposition of forecast error which is explained in very large proportions by unit innovations in itself (ΔP_t^*). Notice that for the period 1976-1988, it reached 100 percent. This result lends support to the notion that the U.S. is a large country relative to Mexico.

Table 4.5. F-Statistics for Granger-Causality Tests[a]

Regressors[b]	Dependent Variable With Estimated V_{t-1} of:					
	Equation 4.3.2		Equation 4.3.4		Equation 4.3.6	
	$\Delta E_t^* \cdot P_t$	ΔP_t^*	$\Delta E_t^* \cdot P_t$	ΔP_t^*	$\Delta E_t^* \cdot P_t$	ΔP_t^*
$\Delta E_t^* \cdot P_t$	15.58 (0.00)	.27 (0.60)	11.62 (0.00)	1.02 (0.42)	8.01 (0.00)	0.00 (0.98)
ΔP_t^*	6.95 (0.00)	40.41 (0.00)	3.86 (0.00)	1.11 (0.37)	4.86 (0.00)	36.29 (0.00)
λ_1		-.0033 (-.39)		.1059 (.97)		-.0114 (-1.09)
λ_2	-.2712 (-5.87)		-.3200 (-2.69)		-.1055 (-1.82)	
FPE[c]	-11.88		-15.97		-11.44	

[a]F-statistics to test the null hypothesis H_0: all lags of a regressor equal zero.

[b]Definitions of the variables are given in Tables 4.1 to 4.4. Numbers under λ_1 and λ_2 are the estimates of the coefficients of the error-correction term, V_{t-1}, the residuals of the corresponding co-integration equation reported in Table 4.3.

[c]Akaike's final prediction error calculated as suggested by Judge, et al., (1985) p. 687, indicated the lag length of the regressors to be equal to one for equations using the lagged residuals of equations 4.3.2 and 4.3.6. For the remaining two regressions the lag length was five.

Numbers in parentheses are the significance levels of the F-statistics, but are t-statistics for λ_1 and λ_2.

Table 4.6. Variance Decomposition of Forecast Error[a]

Forecast Error in	k	Triangular Unit Innovations In[b] $\Delta E_t^* \cdot P_t$	ΔP_t^*	ΔP_t^*	$\Delta E_t^* \cdot P_t$
		First Quarter 1960 to Second Quarter 1988			
$\Delta E_t^* \cdot P_t$	2	95.57	4.43	10.52	89.48
	4	90.86	9.14	16.03	83.97
	6	89.99	10.01	16.95	83.05
	8	89.86	10.14	17.09	82.91
	10	89.84	10.16	17.10	82.90
ΔP_t^*	2	4.49	95.51	99.85	.15
	4	5.04	94.96	99.71	.29
	6	5.13	94.87	99.68	.32
	8	5.14	94.86	99.67	.33
	10	5.14	94.86	99.67	.33
		First Quarter 1960 to Second Quarter 1976			
$\Delta E_t^* \cdot P_t$	2	82.50	17.50	12.18	87.82
	4	85.08	14.92	8.37	91.63
	6	85.46	14.54	6.98	93.02
	8	85.30	14.70	8.01	91.99
	10	84.04	15.96	8.78	91.22
ΔP_t^*	2	11.26	88.74	99.98	.02
	4	29.33	70.67	84.90	15.10
	6	38.16	61.84	77.60	22.40
	8	45.93	54.07	68.84	31.16
	10	47.70	52.30	67.49	32.51
		Third Quarter 1976 to Second Quarter 1988			
$\Delta E_t^* \cdot P_t$	2	94.40	5.60	27.39	72.61
	4	83.93	16.07	39.35	60.65
	6	79.24	20.76	43.72	56.28
	8	77.37	22.63	45.41	54.59
	10	76.60	23.40	46.09	53.91
ΔP_t^*	2	16.21	83.79	100.00	0.00
	4	16.13	83.87	100.00	0.00
	6	16.11	83.89	100.00	0.00
	8	16.10	83.90	100.00	0.00
	10	16.09	83.91	100.00	0.00

[a] Proportions of forecast error k quarters ahead produced by each innovation. Ordering $\Delta E_t^* \cdot P_t$, ΔP_t^* , ΔP_t^* , and $\Delta E_t^* \cdot P_t$. Definitions of variables are given in Tables 4.1 through 4.4. Price levels are the wholesale price index.

[b] Correspond to the innovations w_{1t}, w_{2t}, w_{2t} and w_{1t} respectively.

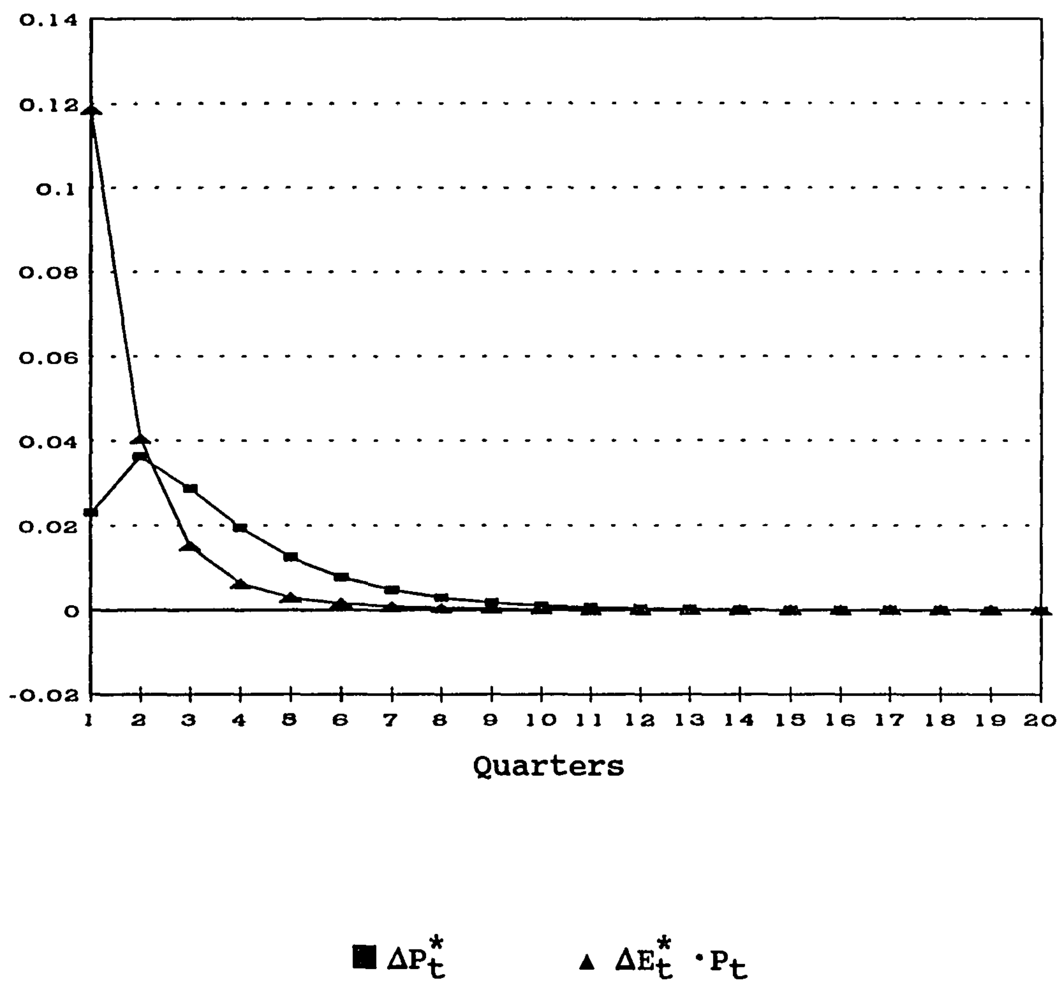

Figure 4.1. Responses of Mexico's Price in U.S. Dollars, $\Delta E^*_t \cdot P_t$ to Unit-shocks, 1960-1988

Source: Equation 4.3.2. The ordering is: ΔP^*_t , $\Delta E^*_t \cdot P_t$.

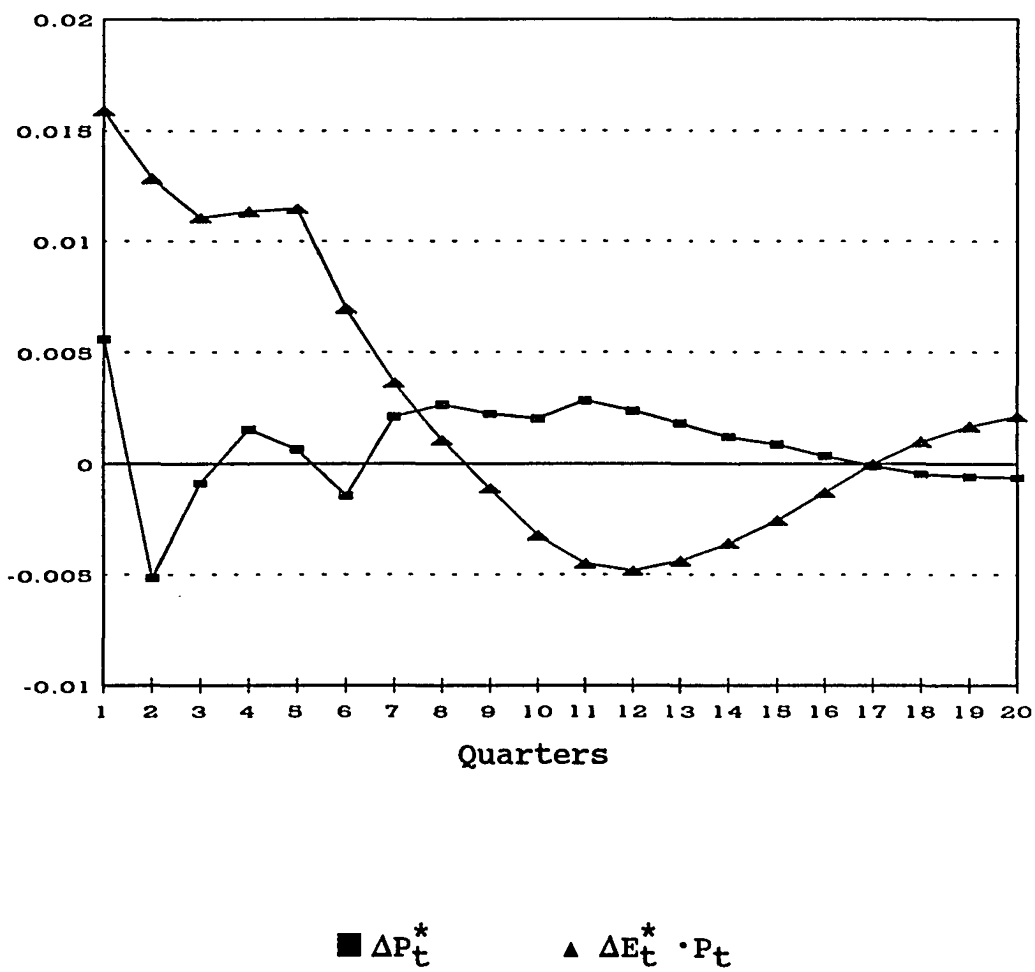

Figure 4.2. Responses of Mexico's Price in U.S. Dollars, $\Delta E_t^* \cdot P_t$ to Unit-shocks, 1960-1976

Source: Equation 4.3.4. The ordering is: ΔP_t^* , $\Delta E_t^* \cdot P_t$.

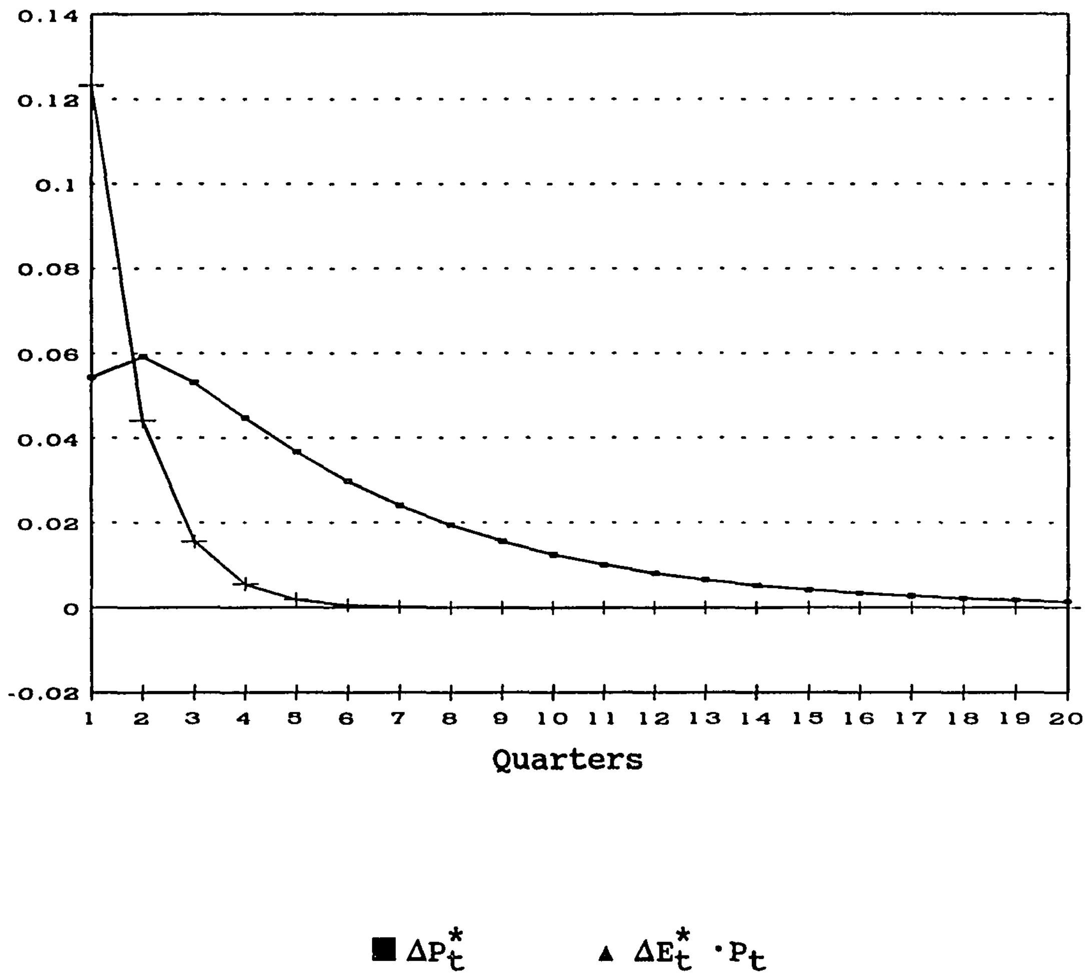

Figure 4.3. Responses of Mexico's Price in U.S. Dollars, $\Delta E_t^* \cdot P_t$ to Unit-shocks, 1976-1988

Source: Equation 4.3.6. The ordering is: ΔP_t^* , $\Delta E_t^* \cdot P_t$.

Next, let us discuss the k-step-ahead impulse response function of $\Delta E_t^* \cdot P_t$ to orthogonal unit shocks in ΔP_t^*. Figures 4.1, 4.2 and 4.3 show the responses of Mexico's price level movements ($\Delta E_t^* \cdot P_t$) to unit innovations in U.S. price changes (ΔP_t^*) for 1960-1988, 1960-1976 and 1976-1988, respectively. Figures 4.1 and 4.3 show a positive response of $\Delta E_t^* \cdot P_t$ to unit innovations in ΔP_t^* which rises during the first two quarters and then decreases over time. This result, together with the F-test for Granger causality and the variance decomposition analysis, supports the notion that Mexican price levels movements respond to U.S. price changes, but not the opposite. In other words, the empirical evidence of this chapter supports the assumptions commonly made in the literature that Mexico is a small country and that purchasing power parity holds between Mexico and the U.S. during the period 1960-1988.

Conclusions

In this chapter co-integration and vector autoregressions (VAR) techniques were used to test whether PPP held between Mexico and the U.S. By way of testing for co-integration between Mexican and U.S. prices expressed in the same currency, the null hypothesis of non-co-integration (e.g. PPP did not hold) was rejected. The data period was from the first quarter of 1960 to the second quarter of 1988. The testing was performed using both consumer and wholesale price indices.

After finding co-integration between the price levels of Mexico and the U.S., an error-correction model was estimated. Furthermore, Granger causality tests derived from the estimated VAR, together with impulse response function and variance decomposition of forecast error, suggest that the Mexican price level and/or the nominal exchange rate adjusted as to maintain PPP during 1960-1988.

That statistical finding also lends support to the assumption, often made in the literature of international economics, that Mexico is a small country, in the sense that it is a price taker in world markets.

CHAPTER 5. THE DEMAND FOR MONEY IN MEXICO: EVIDENCE OF AN ERROR-CORRECTION MODEL AND CO-INTEGRATION

Introduction

The conditions of equilibrium in the money market are of considerable importance in practically all theories that explain aggregate economic activity. A clear understanding and measurement of this market is fundamental in formulating an appropriate monetary policy.

In particular, on the demand side, there have been various estimations of the money demand function using Mexican data. The estimated regressions of these studies have included a measurement of real income and expected inflation which resulted in positive and negative coefficients, respectively.

Recent developments in econometrics, however, allow us to question those results. Specifically, those money demand studies of Mexico do not recognize that if the time series involved in the empirical estimation are not stationary or alternatively, their variables contain unit roots, then the results obtained may be subject to doubt.

On the one hand, if nonstationary variables used in the estimation are entered in levels, then the results will be subject to "spurious regression phenomenon". On the other hand, if the same nonstationary variables enter the estimation in first or second difference form, then a possible long-run relationship might be ignored. A problem with the latter approach is that if the time series involved observe a long-run relationship, then they should be modeled as co-integrated variables and not as first difference variables. This is because differencing removes much of the long-run characteristics of the data. In other words, as Granger (1986) and Engle and Granger (1987) have shown, modeling co-integrated data in differences will result in misspecification error, while modeling the same data in levels will omit important constraints. They suggest modeling co-integrated variables as an error-correction model.

In this chapter, the co-integration methodology suggested by Granger (1986) and Engle and Granger (1987) is applied to quarterly Mexican data with the purpose of empirically estimating a money demand function for the period from the first quarter of 1968 to the first quarter of 1991. This chapter is organized as follows. The following section presents a discussion of an error-correction money demand model, co-integration, and its empirical implementation. Next, the empirical results are reported, and the final section presents some conclusions.

An Error-Correction Money Demand Model and Co-integration

In an inflationary economy the long-run demand for money can be formulated as suggested by Cagan (1956). In Cagan's view the demand for money is a function of a transaction's demand component and an opportunity cost variable associated with real money holdings.[31] Empirically, Cagan's equation of a long-run real money demand can be formulated as equation (1):

$$m_t^d = \beta_0 + \beta_1 y_t + \beta_3 \pi_t + U_t \tag{5.1}$$

where m_t^d is the natural logarithm of the real money demand; β_0 is a constant; β_1 is the long-run income elasticity; y_t is the natural logarithm of real income; β_3 is the long-run semi-elasticity of expected inflation; π_t is the expected rate of inflation; U_t is the long-run random disturbance term; and the subscript t denotes time. The money demand elasticities are assumed to be $\beta_1 > 0$ and $\beta_3 < 0$.

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[31]Most empirical studies of money demand equations include an interest rate instead of an expected rate of inflation. However, in an inflationary economy with a controlled interest rate policy, such an interest rate captures neither market conditions nor an opportunity cost of holding money.

Furthermore, since money market equilibrium may not hold all the time, Goldfeld's postulate of a partial adjustment mechanism is assumed:

$$(m_t - m_{t-1}) = \gamma(m_t^d - m_{t-1}) \tag{5.2}$$

where m_t is the natural logarithm of the real money supply and $0 < \gamma < 1$. To interpret γ, let us rewrite equation (5.2) in a different form:

$$m_t = \gamma m_t^d + (1 - \gamma)m_{t-1} \tag{5.3}$$

Thus, the value of γ, between zero and one, represents the speed of adjustment in the money market. The closer the value of γ to one, the faster the speed of adjustment between the stock of money and the demand for money. Thus if $\gamma = 1$, then $m_t = m_t^d$

Now, substituting equation (5.1) into equation (5.3) we obtain:

$$m_t = \gamma\beta_0 + \gamma\beta_1 y_t + \gamma\beta_3\pi_t + (1-\gamma)m_{t-1} + \gamma U_t \tag{5.4}$$

Implicitly assuming that all variables in (5.4) are stationary, this equation (5.4) has been estimated with data from Mexico. All of those studies provide statistical evidence of positive and negative coefficient estimates for real income and the expected rate of inflation, respectively

(Genel (1971), Rizzo (1972), Díaz de la Garza (1973), Gómez-Oliver (1976), Ortíz (1980a), Ortíz (1980b), and De La Cruz Martínez (1982). However, if m_t, y_t, and π_t are not stationary or alternatively, these time series contain unit roots, then the statistical results of these time series will be questionable.

Stationarity in a variable is an important property for several reasons. First, stationarity guarantees that the effects of a random shock on a variable will die out over time. Second, if nonstationary variables are used in statistical tests any conclusions based upon t- or F-statistics will be misleading. This is known as "spurious regression phenomenon" (Granger and Newbold (1974), Sims, Stock, and Watson (1986), Phillips (1986), and Ohania (1988)). Third, the regression estimators of a regression with unit root variables will not be consistent (Phillips (1986) and West (1988)). And fourth, in estimating long-run or equilibrium relationships, such as a money demand equation, it is important to determine whether the variables are stationary (Granger (1986) and Engle and Granger (1987)).

The traditional model equation (5.4) has been estimated using variables entering a regression in natural logarithms of their respective levels. Therefore, those regression results would be subject to "spurious regression phenomenon" if unit roots were detected in the regressors (Nelson and Plosser (1982) and Engle and Granger (1987)). Furthermore, to avoid such nonstationarity in the regressors, other authors have used variables in first differences (Fackler and McMillin (1983), and Hetzel and Mehra (1989)).

As discussed in Chapters 3 and 4, this differenced-variable approach has also been questioned by the co-integration and error-correction approach (Granger (1986) and Engle and Granger (1987)). They have argued that if the nonstationary time series involved observe a long-run relationship, or their nonstationarity arises from the same common source, then they should be modeled as co-integrated variables. Moreover, the authors suggest modeling co-integrated variables as an error-correction model. Such a model will attempt to capture both a long-run relationship and short-run dynamics in the same regression. The adjustment toward long-run equilibrium will be imposed by an error-correction term, while the short-run dynamics will be captured by the differenced variables, both of which entered the same regression equation. This methodology has been applied to the estimation of money demand equations by Hendry and Richard (1982), Hendry, Pagan and Sargan (1983), Trehan (1988), Small and Porter (1989), Baum and Furno (1990), Hendry and Ericsson (1990), Melnick (1990), Hafer and Jansen (1991), Mehra (1991), Miller (1991) and Mehra

(1993). Most of those studies report estimations using data from industrialized countries. For the case of Mexico, this type of estimation is rare in the literature. Let us describe this modern approach to estimating money demand equations.

The co-integration, error-correction money demand model has two parts. The first part is the long-run equilibrium model and the second part is the error-correction equation. In the long-run equilibrium model, it is assumed that money supply equals money demand and can be represented by equation (5.5):

$$m_t = \alpha_0 + \alpha_1 y_t + \alpha_2 \pi_t + V_t \tag{5.5}$$

where m_t is the natural logarithm of the real money supply; α_0 is a constant; α_1 is the long-run income elasticity; y_t is the natural logarithm of real income; α_2 is the long-run semi-elasticity of expected inflation; π_t is the expected rate of inflation; V_t is the long-run random disturbance term; and the subscript t denotes time. The elasticities are assumed to be $\alpha_1 > 0$ and $\alpha_2 < 0$. Regarding this long-run equilibrium or co-integration equation (5.5), the modern approach considers that individually m_t, y_t, and π_t may be nonstationary while a linear combination of them will be stationary. If this is the case, then these series are said to be co-integrated. More formally, following Granger

(1986) and Engle and Granger (1987), X_{1t}, X_{2t}, and X_{3t} are considered to be co-integrated if the following is satisfied. First, X_{1t}, X_{2t}, and X_{3t} are all integrated of the same order d, i.e., X_{1t}, X_{2t}, and X_{3t} achieve stationarity after differencing them d times denoted as $X_{1t} \sim I(d)$, $X_{2t} \sim I(d)$, and $X_{3t} \sim I(d)$. Second, there exists a vector of constants $(\alpha_1, \alpha_2, \alpha_3)$ such that the linear combination Z_t is stationary. Thus, Z_t will take a form:

$$\alpha_1 X_{1t} + \alpha_2 X_{2t} + \alpha_3 X_{3t} = Z_t \qquad (5.6)$$

In (5.6) if Z_t is stationary, then X_{1t}, X_{2t}, and X_{3t} share a common stochastic trend. Thus, the long-run movements in these time series are related to one another. Furthermore, considering Z_t as V_t, the existence of the long-run money demand specification (5.5) requires V_t to be stationary and m_t, y_t, and π_t to be integrated of the same order. For the time being, let us assume that the long-run money demand (5.5) exists, or, alternatively, let us assume that m_t, y_t, and π_t are co-integrated.

The second part consists of an error-correction model such as equation (5.7):

$$\Delta m_t = \Phi_0 + \sum_{s=1}^{n1} \Phi_{1s} \Delta m_{t-s} + \sum_{s=0}^{n2} \Phi_{2s} \Delta y_{t-s} + \sum_{s=0}^{n3} \Phi_{3s} \Delta \pi_{t-s} + \lambda V_{t-1} + \epsilon_{\Phi t} \qquad (5.7)$$

where all variables are defined as above; Δ is the first difference operator, i.e., $\Delta m_t = m_t - m_{t-1}$; the Φ's are regression coefficients; n1, n2, and n3 are the number of lags of the corresponding variable; V_{t-1} is the lagged value of the long-run random disturbance term; $\epsilon_{\Phi t}$ is the short-run disturbance term; and the subscript t denotes time. The parameter λ in the equation (5.7) is expected to be negative and captures the adjustment of real money balances, Δm_t, toward long-run equilibrium, while the lagged variables in the right-hand side of that equation capture the short-run dynamics of this model.

Notice that as Mehra (1991) pointed out, on the one hand, the existence of the error-correction model equation (5.7), implicitly requires the error term V_t to be stationary. V_t being stationary means that the money supply, m_t, will not permanently drift away from its long-run specification equation (5.5). On the other hand, if V_t

is not stationary, then m_t will permanently drift away from its long-run specification, and thus estimating equation (5.5) will yield results subject to the "spurious regression phenomenon" and the estimates of the coefficients will not be consistent.

To illustrate, first let us take equation (5.5) and lag it one period. Second, using the results obtained in the previous step, take the first difference of equation (5.5) and express the result as equation (5.8):

$$\Delta m_t = \alpha_1 \Delta y_t + \Delta_2 \Delta \pi_t + V_t - V_{t-1} \tag{5.8}$$

Third, assume that V_t follows a first-order autoregressive process such as equation (5.9):

$$V_t = \rho V_{t-1} + \epsilon_{1t} \tag{5.9}$$

where ϵ_{1t} is a white noise error term. Finally, substituting equation (5.9) into equation (5.8), after rearranging terms we obtain:

$$\Delta m_t = \alpha_t \Delta y_t + \alpha_2 \Delta \pi_t + (\rho - 1) V_{t-1} + \epsilon_{1t} \tag{5.10}$$

Letting $\lambda = (\rho - 1)$, equations (5.7) and (10) can be thought of as similar error-correction models. Now, if $0 \leq \rho < 1$ i.e., V_t is stationary, then λ in (5.7) is different from zero. However, if $\rho = 1$, i.e., V_t is not stationary, then $\lambda = 0$. This will mean that an error-correction model would not exist and thus, the first difference approach will be appropriate as a money demand model. Consequently, the modern approach or co-integration approach, equation (5.7), requires V_t to be stationary.

Assuming that V_t in (5.5) is stationary, i.e., the co-integration equation (5.5) exists, the error-correction model (5.7) can be estimated by the Ordinary Least Squares method in two alternative ways. The first alternative involves two steps. The first step requires estimating the long-run equation (5.5) and calculating the estimated residuals of V_t. The second step entails estimating the error-correction model (5.7) using the estimated residuals of V_t, lagged one period, in place of V_{t-1} (Baum and Furno (1990), Melnick (1990), Hafer and Jansen (1991), Hendry and Ericsson (1991), and Miller (1991)). The long-run money demand elasticities are estimated in step one, and the short-run money demand parameters are estimated in step two.

Alternatively, a second method to estimate the error-correction model consists of replacing V_{t-1} by the one-period lag of the long-run money demand equation (5.5), (Small and Porter (1989) and Mehra (1991)). This means that first we lag (5.5) one period and solve it for V_{t-1}. Next, we substitute that result into the error-correction model (5.7) so that the following equation (5.11) is obtained:

$$\Delta m_t = \theta_0 + \sum_{s=1}^{n1} \theta_{1s} \Delta m_{t-s} + \sum_{s=0}^{n2} \theta_{2s} \Delta Y_{t-s} + \sum_{s=0}^{n3} \theta_{3s}\ \Delta\pi_{t-s} + \theta_4 m_{t-1} + \theta_5 Y_{t-1} + \theta_6 \pi_{t-1} + \epsilon_{\theta t} \qquad (5.11)$$

where $\theta_0 = (\Phi_0 - \lambda\alpha_0)$; $\theta_{1s} = \Phi_{1s}$; $\theta_{2s} = \Phi_{2s}$; $\theta_{3s} = \Phi_{3s}$; $\theta_4 = \lambda$; $\theta_5 = -\lambda\alpha_1$; $\theta_6 = -\lambda\alpha_2$; and $\epsilon_{\theta t} = \epsilon_{\Phi t}$. Here, the long-run and short-run money demand elasticities can be recovered from the estimated parameters of (5.11). For instance, the long-run income elasticity α_1 is θ_5 divided by θ_4; the long-run semi-elasticity of the expected rate of inflation α_2 is θ_6 divided by θ_4; and the error coefficient λ is θ_4, (Small and Porter (1989) and Mehra (1991)).

As discussed in Chapters 3 and 4, the empirical implementation of the modern or co-integration, error-correction approach, involves four steps (Granger (1986) and Engle and Granger (1987)).

Step one consists of testing for unit roots or determining the order of integration of m_t, y_t and π_t. Two tests are adopted which are asymptotically equivalent. They are known as the Augmented Dickey-Fuller test (Dickey and

Fuller (1979)) and the Phillips-Perron test (Phillips (1987), Phillips and Perron (1988), and Perron (1988)). These tests are discussed in Chapters 3 and 4, respectively.

Step two is to determine whether the stochastic trends in these variables are related to one another. This is equivalent to determining whether there is a statistical long-run relationship between variables that contain unit roots. We do this by estimating the equilibrium or co-integrating equation (5.5), by the Ordinary Least Squares method.

In the third step the estimated residuals of the co-integration regression, say, V_t, are tested to determine whether they are stationary. Now, if V_t appears to be stationary -- i.e., it does not contain a unit root, while m_t, y_t, and π_t each have a unit root -- then these variables are said to be co-integrated. In that case, ordinary least squares estimators of (5.5) are consistent as shown by West (1988). To test V_t for stationarity we employ three tests: the Dickey-Fuller test (DF), the Augmented Dickey-Fuller test (ADF), and the Phillips-Perron test.

In the fourth step an error-correction model is estimated. This amounts to estimating either the error-correction money demand equation (5.7) or equation (5.11) by the Ordinary Least Squares method. Estimating an error-correction model is important because the existence of co-integrating relationships tells us only about long-run relationships, but not about the short-run dynamics which are also important.

Empirical Results

In this section the empirical results are discussed. Drawing from our discussion of the previous section, we follow four steps. First, unit root tests are performed by estimating the Augmented Dickey-Fuller and the Phillips-Perron regressions for m_t, y_t and π_t. The results of unit root testing these variables' levels are reported in Table 5.1, and the results for their first differences are reported in Table 5.2. Second, the co-integrating money demand regression, equation (5.5), is estimated. Third, the equilibrium regression is tested for co-integration. The results of both step 2 and step 3 are reported in Table 5.3. In the fourth and final step, two alternative error-correction models are estimated and reported in Tables 5.4 and 5.5. Estimating the error-correction models, equations (5.7) and (5.11), will allow us to obtain and compare the long-run money demand elasticities under two different approaches. Both estimation approaches provided similar results.

Table 5.1. Augmented Dickey-Fuller and Phillips-Perron Unit Root Tests

X_t	No Trend[a]			Trend[b]			No Trend[c]		Trend[d]	
	p	ρ	ADF	p	ρ	ADF	α^*	$Z_{(t\alpha^*)}$	$\tilde{\alpha}$	$Z_{(t\tilde{\alpha})}$
m1	8	-.0562	-2.29	8	-.0558	-2.25	.9538	-1.77	.9532	-1.83
m2	8	-.0425	-1.83	8	-.0590	-2.21	.9531	-1.99	.9555	-1.92
m3	6	-.0236	-0.98	6	-.0825	-1.76	.9691	-1.28	.9158	-2.18
y	4	-.0229	-1.80	4	-.0695	-1.89	.9836	-1.46	.9457	-1.52
π	6	-.0514	-1.96	6	-.1129	-2.24	.9555	-1.96	.9538	-2.04

m1 = natural logarithm (M1/CPI); m2 = natural logarithm (M2/CPI); m3 = natural logarithn (M3/CPI); M1, M2, M3 are definitions of money; CPI is consumer price index; y = natural logarithm of industrial production index; π is the rate of inflation.

[a] Values under ρ are OLS estimates of that parameter in $\Delta X_t = \mu 0 + \rho X_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta X_{t-i} + U_t$. The 10%, 5% and 1% critical values to test the null hypothesis H_0: $\rho=0$ are -2.58, -2.89, and -3.51 respectively, Fuller (1976) p. 273.

[b] Values under ρ are OLS estimates of that parameter in $\Delta X_t = \mu 0 + \rho X_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta X_{t-i} + \mu_1 T + U_t$. The 10%, 5% and 1% critical values to test the null hypothesis H_0: $\rho=0$ are -3.15 -3.45, and -4.04 respectively, Fuller (1976) p. 273.

[c] Values under α^* are its OLS estimates in $X_t = \mu^* + \alpha^* X_{t-1} + \overset{*}{U}_t$. The critical values to test the null hypothesis H_0: $\alpha^* = 1$ are given in note a above.

[d] Values under $\tilde{\alpha}$ are OLS estimates of that parameter in $X_t = \tilde{\mu} + \tilde{\beta}(T-N/2) + \tilde{\alpha} Y_{t-1} + \tilde{U}_t$. The critical values to test H_0: $\tilde{\alpha} = 1$ are given in note b above.

Table 5.2. Augmented Dickey-Fuller and Phillips-Perron Unit Root Tests

X_t	No Trend[a]			Trend[b]			No Trend[c]		Trend[d]	
	p	ρ	ADF	p	ρ	ADF	α^*	$Z_{(t\alpha^*)}$	$\tilde{\alpha}$	$Z_{(t\tilde{\alpha})}$
Δm1	8	-.4566	-2.08	8	-.4391	-1.78	.0983	-10.10	.1003	-10.10
Δm2	7	-.4198	-2.10	7	-.4267	-1.82	.3601	-6.44	.3508	-6.43
Δm3	6	-1.0498	-4.23	6	-.1.0631	-4.20	.0112	-9.26	.0120	-9.27
Δy	5	-.9749	-3.72	5	-1.0842	-3.88	.0449	-9.91	.0562	-9.91
$\Delta\pi$	5	-.5063	-3.82	6	-.16195	-4.15	.6804	-3.54	.6771	-3.56

m1 = natural logarithm (M1/CPI); m2 = natural logarithm (M2/CPI); m3 = natural logarithn (M3/CPI); M1, M2, M3 are definitions of money; CPI is consumer price index; y = natural logarithm of industrial production index; π is the rate of inflation.

[a] Values under ρ are OLS estimates of that parameter in $\Delta X_t = \mu 0 + \rho X_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta X_{t-i} + U_t$. The 10%, 5% and 1% critical values to test the null hypothesis H_0: $\rho=0$ are -2.58, -2.89, and -3.51 respectively, Fuller (1976) p. 273.

[b] Values under ρ are OLS estimates of that parameter in $\Delta X_t = \mu 0 + \rho X_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta X_{t-i} + \mu_1 T + U_t$. The 10%, 5% and 1% critical values to test the null hypothesis H_0: $\rho=0$ are -3.15 -3.45, and -4.04 respectively, Fuller (1976) p. 273.

[c] Values under α^* are OLS estimates of that parameter in $X_t = \mu^* + \alpha^* X_{t-1} + U_t^*$. The critical values to test the null hypothesis H_0: $\alpha^* = 1$ are given in note a above.

[d] Values under $\tilde{\alpha}$ are OLS estimates of that parameter in $X_t = \tilde{\mu} + \tilde{\beta}(T-N/2) + \tilde{\alpha} Y_{t-1} + \tilde{U}_t$. The critical values to test H_0: $\tilde{\alpha} = 1$ are given in note b above.

The data are quarter averages of all series for the period from the first quarter of 1969 to the first quarter of 1991. Except for the industrial production index, IPI, all data are taken from Indicadores Economicos, Banco de Mexico. IPI is from International Financial Statistics, line 66, IMF. The definitions of money supply are as follows. M1 is currency in circulation plus demand deposits in domestic and foreign currency. M2 is M1 plus banking instruments with maturity of up to one year plus bankers' acceptances; and M3 is M2 plus CETES, PAGAFES, BONDES and commercial paper. These securities are non-banking liquid investments with a minimum maturity of one year. The money supply enters the regressions in natural logarithm of the monetary aggregate deflated by the consumer price index. They are denoted by the lower case m1, m2, and m3. The variable y_t is the natural logarithm of the industrial production index. The expected rate of inflation, π_t, is proxied by the actual rate of inflation measured by the percentage change in the consumer price index. RATS version 3.11 by Doan (1988) was used in all estimations.

The results of the unit root tests, reported in Tables 5.1 and 5.2, provide statistical evidence that $m1_t$, $m2_t$, $m3_t$, y_t and π_t are all integrated of order one. Thus, their levels are not stationary but their first differences are. This conclusion is supported by both the Augmented Dickey-

Table 5.3. Co-Integration Regressions and Co-Integration Tests[a]

Variable	Coefficients of			R^2	DW	DF[b]	ADF[c]	$Z_{(t\hat{\alpha})}$[d]
	Constant	Y	π					
m1	-1.2810 (-3.17)	.4408 (4.63)	-.3446 (-5.38)	.2883	.1229	-1.65	-2.87	-1.82
m2	-0.6969 (-2.57)	.5745 (8.99)	-.1119 (-2.60)	.5173	.0840	-1.43	-2.59	-1.95
m3	-2.0771 (-12.29)	.9126 (22.74)	-.2718 (-1.83)	.8881	.3427	-2.85	-3.76	-3.67

[a] The OLS residuals from the co-integrating regression, denoted by V_t, are used in the co-integration tests. CPI = Mexico's consumer price index; M1, M2, and M3 are definitions of money supply. m1 = natural logarithm (M1/CPI), m2 = natural logarithm of (M2/CPI), m3 = natural logarithm of (M3/CPI). y = natural logarithm of the industrial production index; π = rate of inflation which is the percentage change in the CPI. R^2 and DW are the coefficient of determination and the Durbin-Watson statistic respectively.

[b] Dickey-Fuller statistics to test the null hypothesis H_0: V_t is nonstationary in $\Delta V_t = -\phi V_{t-1} + \epsilon_{vt}$. The 10%, 5%, and 1% critical values are -3.59, -3.93, and -4.45, Engle and Yoo (1987) p. 157.

[c] Augmented Dickey-Fuller statistics to test the null hypothesis H_0: V_t is nonstationary in $\Delta V_t = -\phi V_{t-1} + \sum_{i=1}^{4} \delta_i \Delta V_{t-i} + \epsilon_{vt}$. The 10%, 5% and 1% critical values are -3.32, -3.62, and -4.22 respectively, Engle and Yoo (1987) p. 158.

[d] Phillips-Perron statistics to test the null hypothesis H_0: V_t is nonstationary in $V_t = \hat{\alpha} V_{t-1} + \hat{U}_t$. The 10%, 5%, and 1% critical values are -3.59, -3.93, and -4.45 respectively, Engle and Yoo (1987) p. 157.

Fuller tests and the Phillips-Perron tests which were performed with and without trends. This is also supported by Perron's unit root tests that account for structural breaks in the time series which are reported in Appendix A. In the Augmented Dickey-Fuller tests, the lag length p, was chosen by the Akaike (1969) criterion. In the Phillips-Perron tests, adjusted t-statistics were calculated for lags 1 to 12. After 8 lags these t-statistics were very similar and so this is the only one reported. The statistical results of Tables 5.1 and 5.2 suggest to continue further and test for co-integration.

Table 5.3 presents the co-integration regressions and their tests for co-integration. Three definitions of money supply were utilized, but only m3 seems to observe a long-run relationship with income and the rate of inflation, i.e. only $m3_t$, y_t, and π_t seem to be co-integrated. Such a conclusion is supported by the Augmented Dickey-Fuller (ADF) test and by the Phillips-Perron (PP) test but not by the Dickey-Fuller (DF) test.[32]

Tables 5.4 and 5.5 show the results of estimating the money demand error-correction for both alternative one,

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[32]A RATS program provided by Dr. Walter Enders and Dr. Barry Falk from Iowa State University, and further modified by the author, was used in the Phillips-Perron unit root tests for co-integration. In the other Phillips-Perron tests, the programs provided with the RATS software were used.

equation (5.7), and alternative two, equation (5.11). For each alternative several models were estimated. All the regressions included seasonal dummy variables (D1, D2 and D3), and dummy variables to account for the nationalization of the banking system (DM824) and for the adoption of a crawling-peg regime in 1976 (DM764). In both cases the maximum number of lags was determined by the final prediction error (FPE) suggested by Akaike (1969) which corresponds to models 5.1 and 5.4. The other models 5.2, 5.3, 5.5, and 5.6 were determined by eliminating the lagged variables of regressors which were not statistically significant.

Moreover, Chow stability tests were estimated for two periods. The first test of the money demand equation for m3 provides no statistical evidence of a structural change from the period of a fixed exchange rate to the crawling-peg regime (August 1976). However, the second Chow tests do provide statistical evidence of a structural change after 1988 (third quarter), when the authorities implemented various economic reforms (see Chapter 2).

The estimates of the error-correction term, λ, the coefficient of V_t in the first alternative and θ_4, the coefficient of $m3_{t-1}$ in the second, are of the correct negative sign and significant in all models. Its size varies from -.16 to -.13. This means that about 16 percent

Table 5.4. Error-Correction Models: Dependent Variable $\Delta m3_t$

Variable	Model 1 Estimate	Model 1 t-value	Model 2 Estimate	Model 2 t-value	Model 3 Estimate	Model 3 t-value
Constant	.0576	9.41	.0572	9.69	.0680	9.54
D1	-.0963	-9.52	-.0983	-10.39	-.1095	-11.06
D2	-.0760	-7.09	-.0752	- 7.42	-.0565	- 5.71
D3	-.0570	-5.41	-.0541	- 6.02	-.0662	- 7.22
DM764	-.0712	-2.49	-.0713	- 2.52	-.0754	- 2.45
DM824	.1500	5.52	.1501	5.61	.1512	5.17
$\Delta\pi_t$	-.4207	-4.84	-.4104	- 4.84	-.3479	- 3.81
$\Delta\pi_{t-1}$	-.0790	-0.82				
Δy_t	.1937	1.66	.2223	2.03	.2639	2.23
Δy_{t-1}	.0310	.26				
$\Delta m3_{t-1}$	.3205	3.65	.3504	4.42	.4322	5.15
$\Delta m3_{t-2}$	.3494	3.80	.3144	4.08		
V_{t-1}	-.1575	-4.28	-.1656	- 4.74	-.1421	- 3.80
R^2	.7844		.7822		.7332	
$\chi^2(1)$	3.22		3.01		2.49	
η_π	-.2718					
η_y	.9126					
FPE[a]	-7.062					
Chow[b]	1.01		1.31		1.21	
Chow[c]	1.90		1.91		1.96	

D1, D2, D3, DM764, and DM824 are dummy variables; Δ is the first difference operator; definitions of π, y, and m3 are given in Table 5.3; R^2 is the coefficient of determination; $\chi^2(1)$ is the lagrange multiplier proposed by Godfrey (1978) to test for first order serial correlation; and η_π and η_y are the long-run money demand elasticities of inflation and income respectively.

[a]Akaike's final prediction error calculated as suggested by Judge, et al. (1985) p. 667, indicated the lag length to equal 1.

[b]Chow test for structural change from the fixed exchange rate to the crawling-peg (fixed rate is up to second quarter 1976).

[c]Chow test for structural change after third quarter 1988.

Table 5.5. Error-Correction Model: Dependent Variable $\Delta m3_t$

	Model 4		Model 5		Model 6	
Variable	Esti-mate	t-value	Esti-mate	t-value	Esti-mate	t-value
Constant	-.3035	-3.41	-.2982	-3.61	-.2661	- 3.03
D1	-.0905	-9.16	-.0913	-9.79	-.0986	-10.12
D2	-.0689	-6.55	-.0701	-7.16	-.5360	- 5.79
D3	-.0549	-5.44	-.0565	-6.58	-.0670	- 7.83
DM764	-.0850	-2.93	-.0797	-2.95	-.0846	- 2.92
DM824	.1454	5.54	.1465	5.69	.1459	5.30
$\Delta\pi_t$	-.4247	-5.11	-.4279	-5.27	-.3821	- 4.45
$\Delta\pi_{t-1}$	-.0379	- .04				
Δy_t	.1448	1.26	.1505	1.40	.1709	1.50
Δy_{t-1}	.0385	.34				
$\Delta m3_{t-1}$	.2394	2.69	.2365	2.79	.2745	3.05
$\Delta m3_{t-2}$	.2744	2.97	.2684	3.58		
π_{t-1}	-.2056	-3.42	-.2022	-3.69	-.2368	- 4.10
y_{t-1}	.1545	4.56	.1524	4.82	.1368	4.09
$m3_{t-1}$	-.1574	-4.46	-.1553	-4.62	-.1330	- 3.79
R^2	.8084		.8081		.7740	
$\chi^2(1)$	3.68		3.06		3.23	
η_π	-1.3062		-1.3010		-1.7819	
η_y	.9813		.9812		1.0285	
FPE[a]	-7.0641					
Chow[b]	.96		1.16		1.33	
Chow[c]	1.99		1.71		1.69	

D1, D2, D3, DM764, and DM824 are dummy variables; Δ is the first difference operator; definitions of π, y, and m3 are given in Table 3; R^2 is the coefficient of determination; $\chi^2(1)$ is the lagrange multiplier proposed by Godfrey (1978) to test for first order serial correlation; and η_π and η_y are the long-run money demand elasticities of inflation and income.

[a]Akaike's final prediction error calculated as suggested by Judge, et al., (1985) p. 667, indicated the lag length to equal 1.

[b,c]See notes b and c in Table 5.4.

(13 percent) of the money supply of the previous quarter's deviation from its long-run equilibrium value will be corrected each quarter. Furthermore, the coefficients for $\Delta\pi$, as expected, are all negative. The coefficients for Δy also have the expected positive sign. Both alternative estimations provide long-run elasticities of the money demand for M3 with respect to income which are about .9 and 1.0. The elasticity of the expected rate of inflation of the money demand for M3 varies from -.3 to -1.7. These elasticities are for the most part similar to the ones reported in other studies of Mexico's money demand equations (Gómez Oliver (1976), Ortíz (1980a), Ortíz (1980b), and De La Cruz Martínez (1982).

Conclusions

In this chapter, quarterly money demand functions were estimated for the period of the first quarter of 1969 to the first quarter of 1991. The methodology applied was that of co-integration and error-correction models. Although three definitions of money supply were tested (m1, m2, and m3), only the aggregate m3 seems to observe a long-run relationship with income and inflation-- that is, only m3, income, and inflation appear to be co-integrated.

While the long-run income elasticity of money demand for M3 seems to be about 1.0, the long-run money demand elasticity with respect to the rate of inflation seems to be between -.3 and -1.3. Furthermore, the estimated money demand error-correction models suggest that somewhere between 13 percent and 16 percent of the previous quarter money supply deviation from its long-run equilibrium value will be corrected within a quarter.

In addition, Chow tests for structural changes in the money demand for M3 provide statistical evidence of a structural change in the period after 1988, but not after the abandonment of the fixed exchange rate regime (August 1976).

Finally, in the case of a small open economy in which the money stock is endogenous, the error-correction regression can be interpreted as the endogenous response of the money-stock growth rate to adjustments in the economy (Miller (1991)). For instance, in the case of Mexico, if the Monetary authorities undertook a fixed or crawling-peg exchange rate regime then the money stock would adjust to equilibrate the balance of payments. In that case Mexico would no longer have control over its monetary policy.

CHAPTER 6. CONCLUSIONS

The preceding chapters consist of three applications of modern time series analysis to data from Mexico. Specifically, co-integration, error-correction, and vector autoregression techniques were applied to balance of payments, exchange rates, and monetary aggregates data to test for the existance of a statistical long-run or equilibrium relationships.

In Chapter 2, an overview of Mexico's macroeconomic performance was presented. This chapter allowed us to identify key dates that were taken as a reference when testing for structural changes in the empirical estimation.

In Chapter 3, the nature of the relationship between domestic credit, international reserves, and the exchange rate embodied in the monetary model of exchange market pressure, was studied for the period from the first quarter of 1971 to the second quarter of 1988. The results obtained suggest the existence of a long-run relationship among those variables --that is, those variables appear to be co-integrated. Furthermore, innovation accounting techniques and multivariate Granger causality tests, performed within an error-correction model, support a bidirectional causality from changes in international reserves and exchange rate to changes in domestic credit, and vice versa. Therefore, first, the implicit assumption of the monetary model of exogenous domestic credit is not supported. Second, the results support the notion that Mexico's monetary authorities adjust domestic assets to neutralize exogenous balance of payments deficits on the monetary base in an attempt to control its money supply.

In Chapter 4, purchasing power parity was examined by way of testing for co-integration between relative prices of Mexico and the U.S., expressed in the same currency. The null hypothesis of non co-integration in the two relative prices was rejected. Thus, the notion that purchasing power parity held in Mexico from 1960-1988 was supported by the statistical analysis. Furthermore, innovation accounting and Granger causality tests derived from the estimated VAR support the finding that Mexican prices and/or nominal exchange rate adjust to maintain PPP.

In Chapter 5, the co-integration and error-correction methodology was applied to estimating a quarterly money demand model. Although three definitions of money supply were used, only the aggregate M3 seems to observe a long-run relationship with income and the rate of inflation. While the long-run income money demand elasticity seems to be about 1.0, the long-run money demand elasticity with respect to inflation appears to be between -.3 and -1.3. Finally, the estimated money demand error-correction models suggest that about 16 percent of the previous quarter money supply deviation from its long-run equilibrium value will be corrected within a quarter. Structural Chow tests performed during the 1969-1991 period detected a structural change in the money demand for M3 only after 1988.

The results obtained in this research do not contradict previous research on the topics studied. Nevertheless, when working with nonstationary time series, one should account for such nonstationarity in order to avoid questionable results.

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APPENDIX A. UNIT ROOT TESTS AND STRUCTURAL BREAKS

Neither the Dickey-Fuller test nor the Phillips-Perron test take into consideration that structural changes may have an effect on the testing for stationarity in economic variables. As Perron (1989) has shown, the Dickey-Fuller and Phillips-Perron tests are biased towards accepting the null hypothesis of a unit root. He concluded that, contrary to Nelson and Plosser's (1982) finding, most U.S. macroeconomic variables turn out to be stationary when proper procedures to account for structural breaks are adopted in the testing.

By applying his newly developed unit root test, which accounts for structural breaks, to the very same variables used by Nelson and Plosser, Perron (1989) concluded that the great crash of 1929 and the oil price shock of 1973 were the main reasons that nonstationarity was found in Nelson and Plosser's analysis. In other words, if structural breaks are explicitly incorporated into the unit root tests, most U.S. macroeconomic series will be found stationary.

Perron (1989) and Rappoport and Reichlin (1989) argued that the Dickey-Fuller test failed to reject the unit root hypothesis because the time series reflected a broken trend. Perron (1989) developed a modified Dickey-Fuller test that considers as a null hypothesis the presence of a unit root in a time series with an alternative hypothesis that the data are stationary about a broken trend. In other words, Perron (1989) developed a procedure for testing the null hypothesis that a given series y_t has a unit root with a drift, and an exogenous structural break occurs at time T_B, against the alternative hypothesis that the time series is stationary about a deterministic time trend with an exogenous change in the trend at time T_B. He developed three models. Here we only consider his model C, which involves estimating the following augmented regression equation:

$$y_t = \mu + \beta_1 DTB_1 + \beta_2 DU_2 + \beta_3 T + \beta_4 DT_4 + \alpha y_{t-1} + \sum_{i=1}^{k} c_i \Delta y_{t-i} + \epsilon_t \qquad \text{(A1)}$$

where the dummy variables are defined as follows. $DTB_1 = 1$ if $T = T_B + 1$, 0 otherwise; $DU_2 = 1$ if $T > T_B$, 0 otherwise; T is a time trend; $DT_4 = T$ if $T > T_B$, 0 otherwise. This model allows for both changes in the level and in the slope of the trend function of the series.

To formally test for the presence of a unit root, Perron suggested using the standard t-statistic for $\alpha = 1$ against his critical values reported in table VI.B, p. 1377 at some confidence level. These statistics depend on the location of the break $\lambda = T_B/N$ (N is the sample size). Reject the null hypothesis of a unit root if the absolute value of the calculated t-statistic is greater than the absolute value of the critical value.

In Tables A1 through A6, the structural unit root tests of the time series of Chapters 3 through 5 of this dissertation are reported. Two structural changes were considered; first, the change in the exchange rate regime of 1976 (T_B = third quarter 1976), and second the external debt crisis of 1982 (T_B = third quarter of 1982). The results suggest that, without exception, all the time series studied contain unit roots in their levels. Therefore, both the Perron tests and the traditional Dickey-Fuller and Phillips-Perron tests support the same results of nonstationarity.

Table A1. Unit Roots Tests with Structural Break
Third Quarter 1976

y_t^a	μ	β_1	β_2	β_3	β_4	α^b
c_t	0.2637	-0.1490	-0.1617	-0.0069	0.0093	-0.7130
	(1.97)	(-1.06)	(-1.08)	(-0.95)	(1.24)	(-1.84)
$(r-e)_t$	0.1070	-0.5703	0.2421	-0.0016	-0.0066	-1.1325
	(0.76)	(-3.59)	(1.41)	(-0.21)	(-0.77)	(-0.46)
a_t	-0.1323	0.5408	-0.5460	0.0055	-0.0015	-0.6850
	(-1.78)	(6.62)	(-0.66)	(1.31)	(-0.36)	(-2.36)
y_t	0.0447	-0.0818	0.0178	-0.0012	0.0002	-0.4715
	(1.51)	(-2.39)	(0.54)	(-0.78)	(0.15)	(-1.35)
π_t	0.0147	0.1087	-0.1014	0.0009	0.0029	0.0984
	(0.36)	(2.39)	(-1.96)	(0.41)	(1.18)	(0.42)
p_t^*	0.0121	-0.0060	0.0025	-0.0002	0.0001	0.6314
	(2.28)	(-1.08)	(0.36)	(-0.91)	(0.32)	(5.20)

[a]Except for c_t and r_t all variables are percentage changes of quarterly data from 1971 to 1988. c_t = change in domestic credit/monetary base, r_t = change in international reserves/monetary base, e_t = peso price of a U.S. dollar, a_t = money multiplier, y_t = industrial production index, π_t = Mexico's rate of inflation, and p_t^* = U.S. rate of inflation.

[b]Under the null hypothesis H_0 $\alpha = 1$, the critical values at 10%, 5%, and 1% are -3.87, -4.17, and -4.38 respectively, Perron (1989, p. 1377, Table VI.B). The time of break relative to total sample size $\lambda = 16/63 = .2540$. In the regression equation, model A1 was used. The value of k, the lag length in model A1, equals six. The structural change analyzed was the third quarter of 1976.

Table A2. Unit Root Tests with Structural Break
Third Quarter 1982

y_t^a	μ	β_1	β_2	β_3	β_4	α^b
c_t	0.1270	0.0091	-0.2470	0.0011	0.0047	-0.5947
	(1.89)	(0.06)	(-0.79)	(0.62)	(0.88)	(-1.54)
$(r-e)_t$	0.0336	0.3357	0.0823	-0.0031	-0.0030	-0.1863
	(0.48)	(1.70)	(1.22)	(-1.37)	(-0.46)	(-0.51)
a_t	-0.0573	-0.0187	-0.5462	0.0007	0.0103	-1.1837
	(-1.28)	(-0.16)	(-2.24)	(0.52)	(2.42)	(-2.64)
y_t	0.0331	-0.0365	0.0476	-0.0001	0.0004	-0.7363
	(2.23)	(-1.05)	(0.67)	(-0.36)	(0.34)	(-1.60)
π_t	0.0028	0.0525	-0.1153	0.0017	0.0028	0.0048
	(0.14)	(0.95)	(-1.14)	(2.54)	(1.56)	(0.01)
p_t^*	0.0089	-0.0094	0.0045	0.0000	-0.0002	0.4653
	(3.18)	(-1.58)	(0.40)	(0.87)	-(1.01)	(2.82)

[a]Except for c_t and r_t all variables are percentage changes of quarterly data from 1971 to 1988. c_t = change in domestic credit/monetary base, r_t = change in international reserves/monetary base, e_t = peso price of a U.S. dollar, a_t = money multiplier, y_t = industrial production index, π_t = Mexico's rate of inflation, and p_t^* = U.S. rate of inflation.

[b]Under the null hypothesis H_0 $\alpha = 1$, the critical values at 10%, 5%, and 1% are -3.86, -4.18, and -4.75 respectively, Perron (1989, p. 1377, Table VI.B). The time of break relative to total sample size $\lambda = 44/63 = .6984$. In the regression equation, model A1 was used. The value of k, the lag length in model A1, equals six. The structural change analyzed was the third quarter of 1982.

Table A3. Unit Root Tests with Structural Break
Third Quarter 1976

y_t^a	μ	β_1	β_2	β_3	β_4	α^b
$E_t^* \cdot P_t$	0.1326	-0.3976	0.3122	0.0032	-0.0020	0.8158
	(2.44)	(-2.72)	(2.08)	(2.63)	(-1.07)	(17.13)
P_t^*	0.0340	-0.0230	-0.0049	0.0007	0.0005	0.9506
	(2.22)	(-0.99)	(-0.12)	(3.12)	(0.83)	(56.08)

[a]Data are quarterly averages of monthly observations from the first quarter of 1960 to the second quarter of 1988.
E_t^* = U.S. dollar price of a Mexican peso; P_t = Mexico's price level; P_t^* = U.S. price level. All variables were normalized to 1 in the first quarter of 1960.

[b]Under the null hypothesis H_0 $\alpha = 1$, the critical values at 10%, 5%, and 1% are -3.95, -4.24, and -4.88 respectively, Perron (1989, p. 1377, Table VI.B). The time of break relative to total sample size λ = 67/114 = .5877. In the regression equation, model A1 was used. The value of k, the lag length in model A1, equals six. The structural change analyzed was the third quarter of 1976.

Table A4. Unit Root Tests with Structural Break Third Quarter 1982

y_t^a	μ	β_1	β_2	β_3	β_4	α^b
$E_t^* \cdot P_t$	0.0627	0.8194	0.1412	0.0036	-0.0015	0.8609
	(1.90)	(4.92)	(0.28)	(2.82)	(-0.32)	(20.81)
P_t^*	0.0020	0.0011	-0.0257	0.0005	0.0001	0.9856
	(0.25)	(0.04)	(-0.31)	(2.34)	(0.15)	(94.30)

[a]Data are quarterly averages of monthly observations from the first quarter of 1960 to the second quarter of 1988.
E_t^* = U.S. dollar price of a Mexican peso; P_t = Mexico's price level; P_t^* = U.S. price level. All variables were normalized to 1 in the first quarter of 1960.

[b]Under the null hypothesis H_0 $\alpha = 1$, the critical values at 10%, 5%, and 1% are -3.69, -4.04, and -4.70 respectively, Perron (1989, p. 1377, Table VI.B). The time of break relative to total sample size $\lambda = 91/114 = .7982$. In the regression equation, model A1 was used. The value of k, the lag length in model A1, equals six. The structural change analyzed was the third quarter of 1982.

Table A5. Unit Root Tests with Structural Break
Third Quarter 1976

y_t^a	μ	β_1	β_2	β_3	β_4	α^b
$m3_t$	0.1777 (2.45)	-0.1163 (-2.39)	0.0209 (0.46)	0.0003 (0.24)	0.0001 (0.07)	0.8911 (18.23)
y_t	0.6577 (3.30)	-0.0823 (-2.57)	0.0928 (2.77)	0.0028 (2.44)	-0.0019 (-2.14)	0.8232 (14.97)
π_t	0.0044 (0.12)	0.0874 (1.91)	0.0000 (0.00)	0.0001 (0.13)	0.0001 (0.13)	0.7257 (5.92)

[a]Data are quarterly averages of monthly observations from the first quarter of 1969 to the first quarter of 1991. m3 = natural logarithm (M3/CPI); M3 is a definition of money; CPI is consumer price index; y = natural logarithm of industrial production index; π is the rate of inflation.

[b]Under the null hypothesis H_0 $\alpha = 1$, the critical values at 10%, 5%, and 1% are -3.95, -4.22, and -4.81 respectively, Perron (1989, p. 1377, Table VI.B). The time of break relative to total sample size $\lambda = 35/93 = .3763$. In the regression equation, model A1 was used. The value of k, the lag length in model A1, equals six. The structural change analyzed was the third quarter of 1976.

Table A6. Unit Root Tests with Structural Break Third Quarter 1982

y_t^a	μ	β_1	β_2	β_3	β_4	α^b
$m3_t$	0.0873	0.0645	-0.2519	0.0013	0.0024	0.9404
	(1.02)	(1.21)	(-2.33)	(1.27)	(1.60)	(14.03)
y_t	1.4553	-0.0140	0.2061	0.0064	-0.0043	0.6044
	(3.42)	(-0.43)	(2.12)	(3.30)	(-2.62)	(5.14)
π_t	-0.0095	-0.0092	0.1660	0.0009	-0.0021	0.5519
	-(0.52)	(-0.19)	(2.10)	(1.83)	(-2.07)	(3.56)

[a]Data are quarterly averages of monthly observations from the first quarter of 1969 to the first quarter of 1991. m3 = natural logarithm (M3/CPI); M3 is a definition of money; CPI is consumer price index; y = natural logarithm of industrial production index; π is the rate of inflation.

[b]Under the null hypothesis H_0 $\alpha = 1$, the critical values at 10%, 5%, and 1% are -3.95, -4.24, and -4.88 respectively, Perron (1989, p. 1377, Table VI.B). The time of break relative to total sample size $\lambda = 59/93 = .6344$. In the regression equation, model A1 was used. The value of k, the lag length in model A1, equals six. The structural change analyzed was the third quarter of 1982.

APPENDIX B. DATA SET

The following data set corresponds to the data utilized in Chapter 3, which were taken from the International Financial Statistics, International Monetary Fund, various issues. The definitions of the time series included are as follows.

R is international reserves, line 79ad;

E is the Peso price of a U.S. Dollar, line RF;

H is the monetary base in billions of Pesos, end of period, line 14;

M1 is money (currency plus demand deposits) in billions of Pesos, end of period, line 34;

MEXCPU is Mexico's consumer price index, line 64;

IPI is Mexico's industrial production, line 66; and

USCPU is the U.S. consumer price index, line 64.

DATE	R	E	H	M1	MEXCPU	IPI	USCPU
71:1	-95	12.50	27	49	2.1	49.2	37.1
71:2	-33	12.50	28	49	2.1	48.1	37.5
71:3	-13	12.50	29	48	2.1	48.0	37.9
71:4	-43	12.50	33	58	2.2	48.8	38.1
72:1	-107	12.50	33	54	2.2	51.4	38.4
72:2	-128	12.50	40	55	2.2	54.5	38.7
72:3	35	12.50	46	55	2.3	53.9	39.0
72:4	-24	12.50	58	68	2.3	54.0	39.4
73:1	-97	12.50	55	65	2.3	56.5	39.9
73:2	47	12.50	59	67	2.4	58.3	40.8
73:3	132	12.50	61	69	2.6	59.6	41.7
73:4	-266	12.50	75	84	2.7	60.9	42.7
74:1	-224	12.50	79	79	2.9	62.8	43.9
74:2	-8	12.50	85	82	3.0	63.5	45.1
74:3	190	12.50	88	82	3.1	62.5	46.5

DATE	R	E	H	M1	MEXCPU	IPI	USCPU
74:4	-36	12.50	105	101	3.3	63.8	47.9
75:1	-96	12.50	111	96	3.4	62.5	48.7
75:2	66	12.50	119	100	3.5	68.4	49.5
75:3	31	12.50	121	98	3.6	66.7	50.5
75:4	-205	12.50	141	122	3.7	66.9	51.3
76:1	11	12.50	140	113	3.9	68.6	51.8
76:2	75	12.50	138	117	4.0	69.3	52.5
76:3	559	15.02	136	124	4.1	68.4	53.3
76:4	-454	21.69	131	158	4.6	65.4	53.9
77:1	-160	22.03	125	147	5.0	66.3	54.9
77:2	8	22.75	155	147	5.2	71.3	56.1
77:3	-228	22.84	164	151	5.4	72.0	56.9
77:4	-57	22.67	296	208	5.6	71.6	57.5
78:1	-45	22.73	299	208	5.9	71.9	58.5
78:2	54	22.76	307	216	6.1	79.2	60.0
78:3	-83	22.81	337	227	6.4	79.6	61.4
78:4	-80	22.77	381	270	6.6	78.5	62.7
79:1	-118	22.76	400	280	7.0	81.6	64.2
79:2	89	22.83	415	284	7.2	83.8	66.4
79:3	58	22.81	435	290	7.5	85.8	68.6
79:4	-185	22.83	513	361	7.8	89.9	70.6
80:1	-33	22.83	536	358	8.6	90.2	73.4
80:2	-206	22.85	568	382	9.0	92.9	76.0
80:3	-158	23.00	601	380	9.6	93.8	77.5
80:4	-288	23.13	722	477	10.1	97.5	79.5
81:1	-183	23.49	745	471	10.9	97.7	81.6
81:2	540	24.09	828	515	11.6	102.3	83.5
81:3	-219	24.79	908	519	12.2	104.4	85.9
81:4	-1414	25.68	1045	635	13.0	103.1	87.1
82:1	1311	34.34	1329	632	14.5	103.1	87.8
82:2	1043	46.77	1415	659	16.7	103.9	89.2
82:3	613	71.18	1757	805	20.2	98.6	90.8
82:4	385	73.32	2068	1031	24.4	94.0	91.0
83:1	-1247	102.02	2184	955	30.8	92.5	91.0
83:2	-452	114.20	2297	1016	36.0	93.4	92.1
83:3	-532	126.12	2605	1041	40.6	90.7	93.2
83:4	-871	138.04	3225	1447	45.7	90.0	94.0
84:1	-769	149.96	3593	1423	53.5	92.7	95.1
84:2	-1385	161.87	3868	1583	60.4	94.5	96.1
84:3	-949	173.73	4191	1611	66.4	95.7	97.1
84:4	-288	185.74	4879	2315	73.3	97.5	97.8
85:1	466	200.57	4828	2226	85.2	99.2	98.5
85:2	753	218.57	4944	2371	93.5	100.6	99.7
85:3	1221	274.75	5080	2648	103.4	100.9	100.4
85:4	-4	333.60	5706	3462	117.8	99.3	101.3
86:1	-139	423.64	6053	3406	142.1	97.5	101.6

DATE	R	E	H	M1	MEXCPU	IPI	USCPU
86:2	1676	522.15	6304	3646	165.6	98.3	101.3
86:3	51	665.69	6484	3795	198.0	90.7	102.1
86:4	-2212	835.61	8444	5790	239.3	92.2	102.6
87:1	-1981	1025.66	8970	6059	297.5	94.8	103.8
87:2	-4846	1241.66	9612	7075	371.4	98.3	105.1
87:3	-772	1460.77	10965	8468	463.8	98.3	106.3
87:4	1628	1784.64	14402	12627	594.3	102.9	107.2
88:1	-2212	2249.42	15675	14055	825.4	99.8	107.9
88:2	1273	2281.00	20044	17484	920.0	99.2	109.2

The following data were utilized in Chapter 4, which were taken from the International Financial Statistics, International Monetary Fund, various issues. The definitions of the time series included are as follows.

USWPI is the U.S. wholesale price index, line 63;

USCPI is the U.S. consumer price index, line 64;

MEXRF is the Peso price of a U.S. Dollar, line RF;

MEXWPI is Mexico's wholesale price index, line 63; and

MEXCPI is Mexico's consumer price index, line 64.

DATE	USWPI	USCPI	MEXRF	MEXWPI	MEXCPI
60:1	30.7219	27.3044	0.0125	1.4815	1.4815
60:2	30.7651	27.4734	0.0125	1.5325	1.5161
60:3	30.6787	27.5445	0.0125	1.5473	1.5789
60:4	30.7219	27.6957	0.0125	1.5351	1.5891
61:1	30.8298	27.7135	0.0125	1.5396	1.5752
61:2	30.5276	27.7224	0.0125	1.5470	1.5634
61:3	30.5276	27.8647	0.0125	1.5344	1.5636
61:4	30.5708	27.9003	0.0125	1.5344	1.5625
62:1	30.7435	27.9537	0.0125	1.5425	1.5775
62:2	30.5816	28.0782	0.0125	1.5658	1.5803
62:3	30.7327	28.2027	0.0125	1.5802	1.5848
62:4	30.6895	28.2649	0.0125	1.5776	1.5973

DATE	USWPI	USCPI	MEXRF	MEXWPI	MEXCPI
63:1	30.5816	28.3094	0.0125	1.5743	1.5948
63:2	30.5276	28.3717	0.0125	1.5795	1.5927
63:3	30.6463	28.5762	0.0125	1.5769	1.5955
63:4	30.6679	28.6563	0.0125	1.5717	1.5946
64:1	30.7111	28.7274	0.0125	1.6164	1.6265
64:2	30.5600	28.7808	0.0125	1.6364	1.6221
64:3	30.6571	28.9053	0.0125	1.6582	1.6310
64:4	30.7435	28.9942	0.0125	1.6586	1.6471
65:1	30.8838	29.0517	0.0125	1.6648	1.6606
65:2	31.1969	29.2585	0.0125	1.6800	1.6949
65:3	31.4236	29.3930	0.0125	1.6733	1.6911
65:4	31.6071	29.5171	0.0125	1.6715	1.7129
66:1	32.0820	29.7549	0.0125	1.6733	1.7354
66:2	32.2224	30.0549	0.0125	1.6829	1.7511
66:3	32.5678	30.3445	0.0125	1.7051	1.7726
66:4	32.3519	30.5720	0.0125	1.7151	1.7854
67:1	32.3411	30.6340	0.0125	1.7391	1.7906
67:2	32.2871	30.8409	0.0125	1.7325	1.8087
67:3	32.4275	31.1718	0.0125	1.7439	1.8234
67:4	32.4922	31.4304	0.0125	1.7550	1.8343
68:1	32.9348	31.7614	0.0125	1.7565	1.8397
68:2	33.1399	32.1233	0.0125	1.7835	1.8473
68:3	33.2695	32.5163	0.0125	1.7816	1.8628
68:4	33.4422	32.9094	0.0125	1.7838	1.8766
69:1	33.9495	33.2817	0.0125	1.7934	1.8560
69:2	34.3921	33.8609	0.0125	1.8016	1.8665
69:3	34.6512	34.3469	0.0125	1.8337	1.9282
69:4	34.9858	34.8227	0.0125	1.8552	1.9287
70:1	35.5040	35.3398	0.0125	1.8766	1.9866
70:2	35.6659	35.9086	0.0125	1.9475	1.9996
70:3	35.8710	36.3120	0.0125	1.9542	2.0268
70:4	35.9250	36.7877	0.0125	1.9435	2.0478
71:1	36.4539	37.0670	0.0125	1.9797	2.0918
71:2	36.8857	37.4910	0.0125	2.0107	2.1153
71:3	37.1772	37.8633	0.0125	1.9937	2.1382
71:4	37.2096	38.0702	0.0125	2.0030	2.1574
72:1	37.8896	38.3701	0.0125	2.0211	2.1846
72:2	38.2674	38.6804	0.0125	2.0510	2.2174
72:3	38.8396	39.0320	0.0125	2.0684	2.2508
72:4	39.2498	39.3837	0.0125	2.0935	2.2774
73:1	41.1496	39.9318	0.0125	2.1841	2.3399
73:2	43.1467	40.8109	0.0125	2.3020	2.4222
73:3	44.9170	41.7107	0.0125	2.4505	2.5528
73:4	45.3056	42.6829	0.0125	2.5935	2.6958
74:1	48.3066	43.8826	0.0125	2.8171	2.9266
74:2	50.0229	45.1237	0.0125	2.9062	3.0287
74:3	53.5744	46.4992	0.0125	2.9520	3.1346

DATE	USWPI	USCPI	MEXRF	MEXWPI	MEXCPI
74:4	55.4419	47.8541	0.0125	2.9827	3.3004
75:1	55.4311	48.7228	0.0125	3.0621	3.4100
75:2	56.0248	49.4881	0.0125	3.1841	3.5114
75:3	57.2230	50.5431	0.0125	3.2887	3.6241
75:4	57.8383	51.3498	0.0125	3.3648	3.6977
76:1	58.1298	51.8462	0.0125	3.5522	3.8586
76:2	58.9826	52.4874	0.0125	3.6663	3.9583
76:3	59.6950	53.3252	0.0150	3.8700	4.0839
76:4	60.2348	53.9250	0.0217	4.6830	4.5963
77:1	61.5625	54.8765	0.0220	5.1745	4.9926
77:2	63.0414	56.0555	0.0228	5.5182	5.2135
77:3	63.1170	56.8726	0.0228	5.7469	5.4364
77:4	63.8618	57.5035	0.0227	5.8282	5.6469
78:1	65.4055	58.4756	0.0227	6.0792	5.9219
78:2	67.3701	59.9960	0.0228	6.4203	6.1261
78:3	68.4064	61.4129	0.0228	6.5777	6.3741
78:4	69.9609	62.6540	0.0228	6.7026	6.5846
79:1	72.4976	64.2156	0.0228	7.1668	6.9742
79:2	75.0776	66.4186	0.0228	7.4632	7.2264
79:3	77.4201	68.6111	0.0228	7.7812	7.5035
79:4	80.1511	70.6176	0.0228	8.0841	7.8473
80:1	83.8753	73.3686	0.0228	8.7758	8.5516
80:2	85.5593	76.0163	0.0228	9.1797	9.0392
80:3	88.3875	77.4539	0.0230	9.8607	9.6331
80:4	90.4277	79.4810	0.0231	10.1422	10.1186
81:1	93.1264	81.5805	0.0235	10.8361	10.9416
81:2	95.2422	83.4731	0.0241	11.5042	11.6043
81:3	95.8899	85.8622	0.0248	12.0885	12.2190
81:4	95.7927	87.0929	0.0257	12.8254	13.0066
82:1	96.6023	87.8065	0.0343	14.3292	14.5277
82:2	96.7103	89.1511	0.0468	16.5549	16.7490
82:3	97.1421	90.8369	0.0712	19.7043	20.2392
82:4	97.2392	91.0230	0.0733	23.1545	24.4046
83:1	97.3040	90.9816	0.1020	29.9668	30.8412
83:2	97.6386	92.1193	0.1142	36.3623	35.9567
83:3	98.5778	93.2259	0.1261	41.0413	40.6451
83:4	99.0528	94.0326	0.1380	45.5570	45.7336
84:1	100.1646	95.0565	0.1500	54.2727	53.4913
84:2	100.8339	96.1011	0.1619	62.7693	60.3509
84:3	100.5964	97.1353	0.1737	68.0713	66.3791
84:4	100.3373	97.8490	0.1857	75.3734	73.3471
85:1	100.1131	98.4902	0.2006	85.0408	85.2472
85:2	100.2101	99.6692	0.2186	95.0003	93.5342
85:3	99.5314	100.4035	0.2748	102.9362	103.4215
85:4	100.1454	101.3033	0.3336	117.0227	117.7971
86:1	98.6266	101.5515	0.4236	142.2610	142.0808
86:2	96.7846	101.3033	0.5222	164.8999	165.5581

DATE	USWPI	USCPI	MEXRF	MEXWPI	MEXCPI
86:3	96.3322	102.0583	0.6657	201.6359	198.0392
86:4	96.6877	102.6375	0.8356	244.7332	239.2574
87:1	97.8187	103.7751	1.0257	295.5879	297.5183
87:2	99.3699	105.1300	1.2417	381.7243	371.3613
87:3	100.5009	106.3090	1.4608	488.5039	463.8182
87:4	100.9856	107.2295	1.7846	609.7737	594.2614
88:1	101.5673	107.8687	2.2494	850.7302	825.4464
88:2	103.2477	109.2317	2.2810	917.5640	920.0475

The following data set corresponds to the data utilized in Chapter 5, which were taken from the International Financial Statistics, International Monetary Fund, various issues; and Indicadores Económicos, Banco de México (the central bank of Mexico), various issues. The definitions of the time series included are as follows.

M1AVG is Mexico's money supply, defined as currency plus demand deposits (M1), expressed as a quarterly average of monthly end-of-period observations, in millions of pesos;

PCAVG is Mexico's consumer price index, expressed as a quarterly average of monthly observations. This index is base 1978 = 100.

M2AVG is Mexico's money supply, defined as M1 plus banking instruments with maturity of up to one year plus bankers' acceptances (M2). It is expressed as a quarterly average of monthly end-of-period observations, in millions of pesos;

M3AVG is Mexico's money supply, defined as M2 plus CETES, PAGAFES, BONDES and commercial paper. These securities are non-banking liquid instruments with a minimum maturity of one year (M3). M3 is also expressed as a quarterly average of monthly end-of-period observations, in millions of pesos; and

IPI is Mexico's industrial production, line 66.

The series for IPI is taken from the International Financial Statistics, International Monetary Fund. The rest of the series are taken from the central bank of Mexico.

DATE	M1AVG	PCAVG	M2AVG	M3AVG	IPI
69:1	37.6	30.3	107.7	107.7	45.80
69:2	37.7	30.4	111.9	111.9	45.70
69:3	37.8	30.8	116.3	116.3	44.50
69:4	40.4	31.4	122.9	122.9	44.60
70:1	41.6	31.8	128.8	128.8	46.00
70:2	41.4	32.0	133.4	133.4	49.40
70:3	41.5	32.5	137.9	137.9	47.70
70:4	45.0	32.8	145.6	145.6	47.50
71:1	45.0	33.5	151.5	151.5	49.20
71:2	44.7	33.9	155.8	155.8	48.10
71:3	44.6	34.2	159.5	159.5	48.00
71:4	48.1	34.5	165.8	165.8	48.80
72:1	50.4	34.9	171.5	171.5	51.40
72:2	50.3	35.5	176.7	176.7	54.50
72:3	51.9	36.0	185.2	185.2	53.90
72:4	57.8	36.4	195.4	195.4	54.00
73:1	61.5	37.4	204.8	204.8	56.50
73:2	63.2	38.8	209.4	209.4	58.30
73:3	65.5	40.8	214.9	214.9	59.60
73:4	72.9	43.1	223.2	223.2	60.90
74:1	75.1	46.8	228.5	228.5	62.80
74:2	77.1	48.4	239.2	239.2	63.50
74:3	78.5	50.1	247.9	247.9	62.50
74:4	87.2	52.8	260.3	260.3	63.80
75:1	91.2	54.5	276.6	276.6	62.50
75:2	94.9	56.1	295.3	295.3	68.40
75:3	96.1	58.0	309.3	309.3	66.70
75:4	106.4	59.1	331.7	331.7	66.90
76:1	110.1	61.7	346.6	346.6	68.60

DATE	M1AVG	PCAVG	M2AVG	M3AVG	IPI
76:2	112.6	63.3	357.9	357.9	69.30
76:3	116.4	65.3	366.7	366.7	68.40
76:4	138.9	73.5	384.1	384.1	65.40
77:1	143.7	79.9	404.4	404.4	66.30
77:2	144.2	83.4	422.8	422.8	71.30
77:3	147.2	87.0	444.4	444.4	72.00
77:4	173.0	90.3	488.7	488.7	71.60
78:1	186.2	94.7	533.4	535.2	71.90
78:2	194.6	98.0	571.4	573.4	79.20
78:3	202.6	102.0	609.4	611.5	79.60
78:4	231.3	105.3	663.4	665.7	78.50
79:1	253.2	111.6	721.3	735.7	81.60
79:2	268.6	115.6	773.7	789.2	83.80
79:3	273.3	120.0	821.6	838.0	85.80
79:4	309.7	125.5	898.7	916.7	89.90
80:1	332.9	136.8	977.8	1008.3	90.20
80:2	348.9	144.6	1056.1	1089.1	92.90
80:3	366.4	154.1	1128.7	1163.9	93.80
80:4	416.9	161.9	1239.4	1278.1	97.50
81:1	447.3	175.0	1371.7	1420.5	97.70
81:2	480.3	185.6	1525.7	1579.9	102.30
81:3	483.1	195.5	1669.3	1728.6	104.40
81:4	550.3	208.1	1850.8	1916.6	103.10
82:1	595.0	232.4	2199.7	2376.1	103.10
82:2	618.3	267.9	2388.4	2579.9	103.90
82:3	694.7	323.8	2739.3	2959.0	98.60
82:4	915.3	390.4	3147.1	3399.5	94.00
83:1	928.4	494.7	3491.0	3766.0	92.50
83:2	954.3	575.2	3821.1	4122.1	93.40
83:3	1025.0	650.2	4292.1	4630.2	90.70
83:4	1232.2	731.6	4957.5	5348.1	90.00
84:1	1347.3	855.7	5729.3	6191.7	92.70
84:2	1493.7	965.4	6498.9	7023.5	94.50
84:3	1578.1	1061.9	7306.1	7895.8	95.70
84:4	1963.8	1173.3	8330.2	9002.6	97.50
85:1	2178.7	1363.4	9203.0	9969.6	99.20
85:2	2307.1	1496.3	9883.3	10706.6	100.60
85:3	2516.9	1654.4	10622.0	11506.8	100.90
85:4	3010.5	1884.4	12153.3	13165.7	99.30
86:1	3389.8	2272.9	13886.4	14926.7	97.50
86:2	3672.3	2648.4	16225.7	17305.0	98.30
86:3	3986.6	3168.0	18649.5	20262.7	90.70
86:4	5137.2	3827.4	22832.5	25683.3	92.20
87:1	6092.3	4759.4	28297.3	32819.7	94.80
87:2	7260.8	5940.7	35642.2	42004.0	98.30
87:3	8638.8	7419.7	42798.6	53215.7	98.30
87:4	12009.3	9506.5	53871.2	66829.0	102.90

DATE	M1AVG	PCAVG	M2AVG	M3AVG	IPI
88:1	14531.1	13204.4	64965.8	83878.0	99.80
88:2	17351.0	14718.1	73688.7	100919.0	99.20
88:3	18426.7	15384.7	75958.3	104533.3	97.90
88:4	20817.7	15857.6	81917.7	116400.0	104.50
89:1	20445.3	16752.8	81593.0	127800.0	103.30
89:2	21365.7	17430.8	86628.0	141533.3	107.10
89:3	22717.3	17998.0	95604.0	156233.3	104.00
89:4	27256.3	18821.0	111903.3	172333.3	107.60
90:1	28655.3	20688.3	119467.5	187035.3	108.50
90:2	32163.6	21814.6	130385.5	207039.3	109.70
90:3	32899.0	23031.8	140494.9	219639.7	111.00
90:4	44741.0	24931.3	167293.2	246342.0	116.17
91:1	48619.7	26177.0	183969.0	262702.0	112.83